IBM Rochester @ 50

Commemorating our past
Celebrating our present
Charting our future

1956-2006

Fifty years ago, on February 8, 1956, IBM® President Thomas J. Watson, Jr. met with Rochester business, professional, and civic leaders at the Kahler Hotel and announced that after a quiet review of several Midwestern cities, IBM had selected Rochester, Minnesota, as the location of its newest facility.

Our beginnings in Rochester were the start of an amazing journey – a journey of innovation and change. The travelers on this journey have been a group of talented, dedicated individuals who work in a vibrant community. They have a guiding vision that providing innovative solutions to information processing challenges will enhance businesses, governments, organizations, and the quality of life itself. No one could have envisioned the magnitude of technological change we have created during the past 50 years, and no one can chart the next 50 years of innovation. That's what makes what we do at IBM truly exciting and full of discovery.

The track record of IBM Rochester innovation has been nothing less than astounding. On our first day of operation, we built electromechanical collators which processed punched cards at a rate of four per second. Fifty years later, IBM Rochester is home of the world's fastest supercomputer, capable of performing complex computations at a rate of 280 trillion operations per second! The legacy of our employees has made it possible to build upon our skills and allowed us to reinvent ourselves as the needs for technology change. To our present and former employees, our IBM colleagues around the world, and to our clients with whom we partner, a special thanks for helping IBM Rochester make its mark on IBM's history.

Our special thanks are also extended to Professor Arthur Norberg and Dr. Jeffrey Yost of the University of Minnesota Charles Babbage Institute for their careful and thoughtful documentation of our history. They carefully placed IBM Rochester in the context of IBM's history, which will reach 100 years in 2011. We have much to celebrate!

Throughout its 50-year history, IBM Rochester has shown its ability to continually adapt, along with the IBM Corporation, to meet the challenges of an ever-changing global marketplace. Rochester employees recognize that their future relies not only on developing, manufacturing, and supporting the systems on which our clients operate, but on continually working to find innovations that matter in the world.

Walt Ling
IBM Vice President
Rochester Senior Location Executive
Minnesota Senior State Executive

Table of Contents

The 397-acre site near Route 52, located two miles northwest of the city of Rochester, was purchased by IBM in 1956 for its new Rochester manufacturing facility.

IBM Rochester: A Half Century of Innovation

Throughout its nearly 100-year history, International Business Machines (IBM) has helped pioneer information technology. Nearly all of its products have been designed and developed to record, process, communicate, store, and retrieve information – from scales, tabulators, and clocks to powerful computers, vast global networks, and customized solutions and services for its customers.

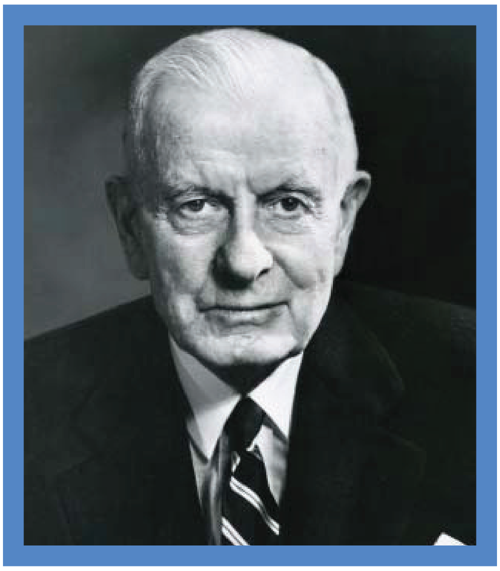
IBM's Beginnings

The company originated from the technological ingenuity and business acumen of Hermann Hollerith, a pioneer developer of punch card tabulation machines in the mid-1880s. These machines were designed to mechanically augment the processing of information to achieve greater speed and accuracy. Hollerith's tabulating machines were used on the most demanding information or data processing tasks of the time, the 1890 and 1900 U.S. Censuses, as well as by dozens of firms in the railroad, insurance, and other industries in the early twentieth century.

In 1911, Hollerith sold his enterprise, the Tabulating Recording Company, to Charles Flint, who combined it with two other firms to form the Computing-Tabulating-Recording Company, or C-T-R. The company was renamed International Business Machines, or IBM, in 1924 to reflect the company's broadening line and growing foreign operations. For more than a decade, the Hollerith enterprise had served European markets and continued to expand operations and facilities in the region. In spite of its great success in the 1910s and 1920s, C-T-R/IBM was considerably smaller than Remington Rand (a diversified office equipment producer with a substantial tabulating machine division), National Cash Register, and the Burroughs Corporation – the other three U.S. office machine giants. This would soon change as IBM continued to be successful during the challenging economic times that lay immediately ahead.

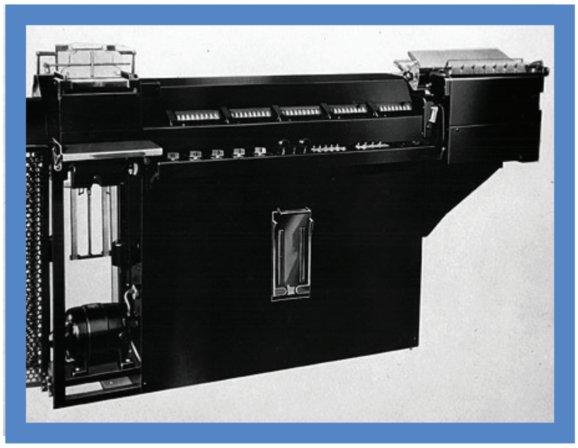
IBM's Emergence as the World Leader in Business Machines and Data Processing, 1928-1945

During the first decade of the Great Depression that followed the stock market crash of October 1929, IBM surpassed the other three U.S. office machine giants in profitability. The company, led by Thomas Watson, Sr., since 1915, achieved this through its lease structure; sales and service capabilities; the steady and predictable income from its growing market dominance in punch cards; and its success in increasing installations of its unit record equipment. This equipment included key punches, card readers, tabulating machines, sorters, collators, reproducers, and calculators. Despite the challenges of the Great Depression and its overall negative impact on the demand for data processing in the private sector, the firm benefited from the increasing demand for data processing in the public sector. The latter was in large part attributable to new statistics kept by the federal government and particularly the increased needs for maintaining records and processing information that arose with the Social Security Act of 1935.



Thomas J. Watson, Sr. was the first president of IBM. Watson developed the principles that guided IBM from a small firm to a successful international company.

In 1928, IBM introduced its 80-column punch card; previously the firm and its largest competitor, Remington Rand, had utilized the same 45-column card. IBM's 80-column card was developed by one of its senior machine designers, Clair D. Lake, an individual who was recruited by Watson, Sr. in 1915 from the Locomobile automobile plant in Bridgeport, Connecticut. Lake's 80-column card, in addition to nearly doubling card storage capacity, utilized rectangular rather than round holes. This innovation provided more efficient space utilization for the wire brushes that electrically detected the holes in the card. Rectangular holes also proved mechanically stronger and were successfully patented.



The IBM Type 285 Numeric Printing Tabulator, presented in 1933, was one of the longest-lived IBM products of the tabulator era.

Another factor in IBM's success in punch cards and tabulation installations during the interwar period was IBM offered a "reproducer," a device that transferred data on existing 45-column cards to the new 80-column cards. While IBM's primary competitor in tabulation machines and cards, Remington Rand, countered two years later with a 90-column card, it was already too late. Remington Rand's cards were incompatible with IBM's. Given this, customers had to make a choice and they overwhelmingly chose IBM. In this regard IBM not only benefited from being first but also by having a larger place in the tabulation machine and punch card market. Although Remington Rand was still the largest overall office equipment firm in the 1930s, the tabulation machine and punch card division was considerably smaller than IBM's. Most importantly, given the nature of punch cards and their uses, customer choice led to a significant degree of product lock-in, benefiting IBM greatly over the long term.

In the same year that Lake developed the 80-column card, his group also designed the Type IV tabulator, a machine that in conjunction with the new card facilitated the storing and processing of negative numbers. This was soon followed by IBM's development of the Type 600 multiplying punch, which was put into production in 1931 and facilitated multiplication. Based in large part on the work of James Bryce, an engineer Watson had hired in 1917 who became chief engineer in 1922 and served as Watson's chief technical advisor, it could take two factors off a card, multiply them, and punch out the product on a blank field on the same card. This was followed, in 1933, with the introduction of the Type 601 electric multiplier, a machine that among other advances could perform "crossfooting," or the summing of numbers by row rather than column.

Watson's determination to continue to invest in people, manufacturing, and technological innovation, despite the difficult economic times brought on by the stock market and the Great Depression, helped IBM achieve and solidify its position as the leading office machine producer and data processing firm in the world.

In addition to the predictable revenue streams from its cards and its long-term leasing of machines, the government's increased need for data processing contributed to IBM's great success relative to its industry peers during the 1920s and 1930s. Watson fearlessly plowed this revenue back into the firm to invest in the extension of technical capabilities and to develop and refine products. This investment was important to IBM's maintaining and increasing market share during the 1930s and led to important new products. For instance, the Type 285 Numeric Printing Tabulator was introduced in 1933 and the Type 405 Alphabetic Accounting Machine came out the following year. Both machines operated at unprecedented speeds for their class, could tabulate 150 cards per minute, and were successful in the marketplace relative to competitors' products. The Type 405 provided even greater versatility, processing both numeric and alphabetic data. Watson's willingness to invest in the firm in difficult times also solidified and extended the great support and respect he had from his workforce.

Equally significant to the individual products and the corporate culture Watson had created was the associated increase in infrastructure for innovation at IBM. During the 1930s, IBM greatly increased its research and manufacturing capabilities and instituted formalized programs for employee education. In 1933, Watson shifted much of IBM's research and design activities to Endicott, New York, its primary manufacturing facility, by building the North Street Laboratory. Consolidating manufacturing and development operations at facilities proved a winning combination over the years.

With regard to education, the firm instituted a program of evening classes in the early to mid-1930s. It offered courses in blueprint reading, shop mathematics, measuring instruments and techniques, modern milling, grinding practice, electricity, and many other topics. Roughly, two dozen different courses were offered by the mid-1930s. These 36-week, one-night-a-week courses were optional, yet about half of Endicott's 3,200 manufacturing employees were enrolled to help advance their careers within the company.

Thomas Watson, Sr. came from a sales background. He worked for the legendary father of salesmanship, John Patterson, at NCR prior to joining C-T-R in 1915. Throughout his leadership of IBM, Watson showed a commitment to his sales team. He hired a significant number of new engineers during the Depression years and took advantage of the opportunity to add some quality technically trained individuals who had been let go by other firms. Both his product development engineers and sales personnel continued to deliver and add to the firm's achievement.

During the early years of the Depression, it was a success if office machine companies could just stem the tide of rental returns. In time, however, the IBM team added new installations of tabulation machines (often rentals rather than sales) and continued to sell millions of punch cards. In fact, these remained an important source of revenue and profits for many years, well into the digital computer era. As late as the mid-1950s, punch card sales made up 20 percent of the firm's top line, and even more impressively, 30 percent of its bottom line. In short, IBM was a firm that invested heavily in technical development and sales capabilities, education to expand them, and a commitment to grow rapidly in the data processing field. This took the company into a new area in the early post-World War II period, electronic digital computing – a product area strongly pushed by the heir apparent to the legendary Watson, Sr., his son, Thomas Watson, Jr. This new product area grew alongside unit record equipment from the early to mid-1950s through the 1960s. Over time, as digital computers became far cheaper relative to their expanding capabilities, these machines became a textbook example of creative destruction, a fundamental trait of any innovative high technology firm that succeeds and remains innovative over the long term.

IBM's Extension of Its Data Processing Leadership into Digital Computing

Throughout the final years of the Depression, IBM continued to build on its leadership in the United States and internationally in the office machine and information processing fields. The firm also showed an early interest and dedication to computing technology in collaborating with Harvard University on a project led by Howard Aiken to build the most powerful electromechanical calculating machine in existence: The IBM Automatic Sequence Controlled Calculator or Harvard Mark I. This $200,000 project, which began in 1941 and was completed in 1943 (dedicated in 1944), produced a 51-foot long, eight-foot high machine that was used for calculating mathematical tables for the U.S. Navy during the war and for a variety of scientific and engineering calculations for different organizations in the early post-war era.

During the late 1940s and early 1950s, while IBM lagged, a small number of firms and organizations including the University of Pennsylvania, Engineering Research Associates (ERA), Electronic Control Company/Eckert-Mauchly Computer Company, Remington Rand, and the Institute for Advanced Study (IAS), built digital electronic computers. IBM, behind the leadership of Thomas Watson, Sr., and his son Thomas Watson, Jr., (who became president in 1952 and CEO in 1956), showed great business acumen in building a machine that could both

perform and be priced at a level where considerable market opportunities were developing. IBM came out with its first digital computer in 1953, the IBM 701 (Defense Calculator), which it followed with the IBM 650, the most popular digital computer of the 1950s. The IBM 650 has been referred to as the Model T of computing, an apt description in terms of volume relative to competing digital computers and one appropriately conjuring notions of large-scale production of a complicated technology with thousands of components. The IBM 650 and other digital computers, however, had a substantially different market – government agencies, universities, and larger businesses – than the middle class and upper class consumers purchasing Model Ts in the 1910s and 1920s.

The IBM Defense Calculator, prototype of the first IBM digital computer, the IBM 701, was developed in the early 1950s.

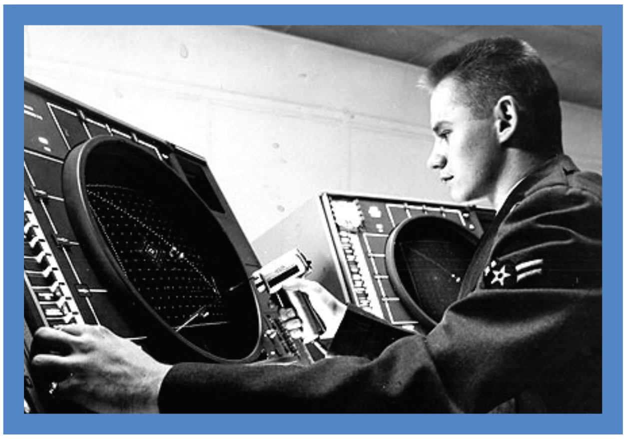
The IBM System/360, one of the most successful computer systems, was brought to market in the mid-1960s. Prior to the System/360, IBM computer models were designed independently. This changed with the System/360 family of computers which offered considerable compatibility and economies in design and manufacturing.

Though much of the early funding for digital computing extended from the Department of Defense and its war-related needs, the military did not diminish as a major supporter of computing technology at war's end. This was a result of the United States' near immediate entrance into the Cold War. IBM benefited greatly from working on major Department of Defense-supported computer development projects in the 1950s. Of these, none was more important than the Semi-Automatic Ground Environment (SAGE) early detection air defense system. In 1954, IBM was named as the primary computer hardware contractor for this massive computing and communications system.

While SAGE was a large revenue generator for IBM, Project STRETCH, for Los Alamos National Laboratory was not. The STRETCH computer did not fulfill its original project specifications, nevertheless it was the most powerful computer in the world for a brief time in the early 1960s. Key technologies of this advanced computer system were fundamental to the IBM System/360™ series developed in the mid-1960s. The IBM System/360 series of compatible machines was a major investment for the firm and a considerable business risk, but turned out to be a tremendous success. It allowed customers to upgrade within the mainframe series without having to develop new software therefore eliminating the costly burden of needing to reprogram application software. It also helped facilitate the growth of both the plug-compatible equipment and software products industries.

IBM broke new ground with its 1957 delivery of the IBM 305 Random Access Method of Accounting and Control (RAMAC®), the first computer disk storage system. That same year it introduced FORTRAN, a highly influential programming language that became the language of choice in scientific computing for decades. It also supported outside software users groups of customers of IBM computer systems such as SHARE, which started in Los Angeles in 1955 primarily among the firm's aerospace customers, and GUIDE, another IBM customer user group,

IBM Rochester had a role in the production of the company's new STRETCH computer – at the time the fastest and most powerful in the world.



Developed by IBM in the mid-1950s and deployed across North America, the SAGE air defense system was the first large computer network to allow "real time" interactive communication with its operators. SAGE contributed to the development of the Semi-Automatic Business-Related Environment (SABRE), an airline reservation system produced in partnership with American Airlines in 1964.

initially for IBM 702 and 705 mainframe users that began the following year. Later, COMMON was established to serve the community of IBM midrange users providing information, education, and networking among users, IBM, and related third-party solution providers. Like its predecessors, COMMON facilitates IT knowledge sharing, education, problem solving, and industry influence for the IBM user group community.

IBM built upon its experience in networking with SAGE and partnered with American Airlines to produce the Semi-Automatic Business-Related Environment (SABRE), a system that became operational in 1964. Four years later the firm introduced its Customer Information Control System (CICS®), an influential and widely used transaction monitor system. While a 1952 Department of Justice anti-trust case had resulted in the 1956 Consent Decree that forced IBM to sell hardware on as favorable terms as leases, spin-off its service bureau as the independent Service Bureau Corporation, and provide manuals and other replacement equipment to outside service firms, IBM continued to thrive with net earnings growing roughly five-fold during the 1960s.

A key factor in IBM's leadership in office machines and information processing was the firm's attentiveness to customers and its excellent sales and service infrastructure. This was equally true with tabulating machines, digital computers, and other products. In the 1950s and 1960s, IBM demonstrated an ability to know when to capitalize on the development of digital computers, what types of machines to produce, and what rental and sale prices would lead to establishing new markets for maintaining and extending its long-term relationship with customers.

During these two decades, the firm also showed skill in continuing to produce and innovate electromechanical and electronic equipment for existing markets, including accounting machines, sorters, time system and recording machines, calculating punches, and typewriters. In the mid-1950s, a period of rapid national and international growth in tabulation machines, punch cards, typewriters, and electronic digital computers, IBM was looking to expand its operations substantially. A number of options were considered and several key strategic decisions were made – perhaps none as important as a decision to add a new manufacturing facility in a carefully selected smaller city in the Midwest. This was a decision that rapidly paid dividends and one that must have greatly exceeded even the most optimistic expectations of Thomas Watson, Jr., who, in 1956, had just recently taken over the leadership of the firm from his father following Thomas Watson, Sr.'s passing.

Origins of IBM Rochester

While new product development; excellence in sales and service; steady income from tabulation machines, punch cards, and electromechanical equipment; and dwarfing its competition in the mainframe digital computer field were fundamental to the company's continued high achievement at mid-century and beyond, successful manufacturing operations continued to be critically important to IBM as well. As the firm grew, it looked to strategic areas to add new facilities with characteristics particularly conducive to stability and long-term manufacturing success.

Unlike other major firms in the U.S. office machine industry – Remington (later Remington Rand, and then, Sperry Rand), Burroughs, and National Cash Register (NCR) – IBM maintained and even increased its productive capacity in the time between the advent of the Great Depression in 1929 and the start of World War II. During the war, IBM further accelerated the growth of its productive capacity as Thomas Watson, Sr. placed all IBM facilities at the disposal of the government in July 1940, after the National Emergency Proclamation found the firm to be a potential supplier of war-related materials and products. IBM expanded manufacturing space with new facilities in Poughkeepsie and Endicott, New York, and in Washington, D.C. In 1943, IBM expanded to San Jose, California, to establish its presence on the West Coast – an insightful and fortuitous move that contributed to and took advantage of the growing base of electronics and other high technology in coastal California. Along with facilities in New York, it became a key manufacturing and development facility for the firm. In 1952, IBM San Jose initiated a development laboratory (to develop disk drives); a pattern of combining manufacturing and development laboratories in a single facility that the corporation would later follow in Rochester, Minnesota.

At mid-century, labor costs were significantly higher on the two coasts and in larger cities throughout the country than in the towns and smaller cities of middle America. A substantial, untapped labor supply existed in this region, and labor organization and labor unrest was far less pervasive than in large urban areas of the nation. When IBM decided it needed to further expand manufacturing capacity in the mid-1950s, it evaluated many smaller cities and larger towns in America's heartland as possible locations for a new IBM facility. In all, more than 80 Midwestern cities were considered by IBM. Two of the finalists at the start of 1956 were Rochester, Minnesota, and Madison, Wisconsin. A major report by the corporation evaluated these two potential sites and both were viewed as attractive locations.

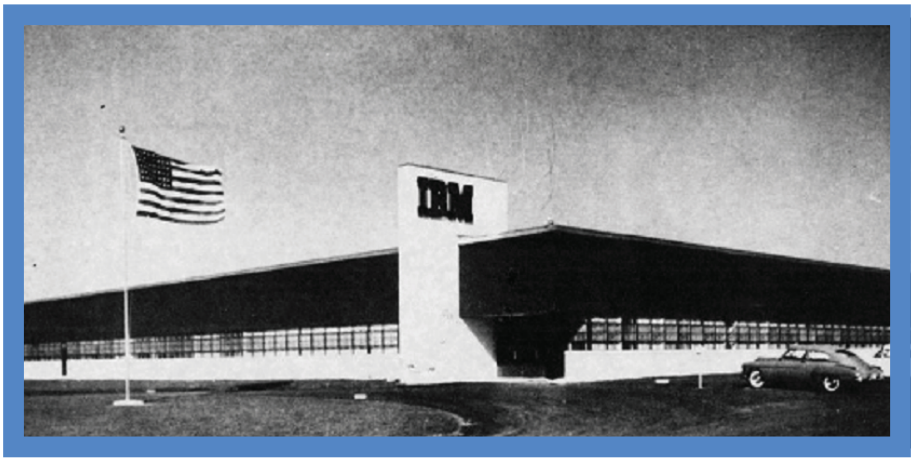
Availability of a quality labor force, schools, morals and manners, taxes, transportation and utilities infrastructure, and many other criteria were carefully assessed, with both communities receiving high marks. With regard to Rochester, there was modest concern that it might not have a large enough labor supply and careful evaluation was made to decide if the city could grow with the company. In Madison, the size of the available labor force was less of a concern than the higher wages, the stronger presence of national labor organizations, and the trend toward future wage pressures given existing industry in the city. These factors, coupled with all the many positive attributes of Rochester, from its strong schools, friendly community, transportation infrastructure, and moderate and locally-oriented labor organization, led to the choice of Rochester.

In spite of the fact that the largest existing industrial operation in Rochester at the time, the Libby, McNeil & Libby canning plant (that processed peas and corn), was a seasonal operation that employed 750 people between August and September – but only 75 people year round – there was considerable social, cultural, transportation, and educational infrastructure in Rochester. This was the result of a diverse base of smaller employers, and more importantly, the existence of one of the premiere medical treatment and research facilities in the world, Mayo Clinic. With roots from the late 1800s, Mayo Clinic's formation in Rochester in 1914 led to such elegant establishments as the Kahler Hotel which was completed in 1921. Both IBM Rochester and the Mayo Clinic contributed to the economic, population growth, and development of Rochester. This enhanced the level of amenities and quality of life in the city throughout the remainder of the twentieth century and into the twenty-first century.

IBM Rochester: Breaking New Ground

It was after a daytime meeting between Thomas Watson, Jr. and 40 Rochester business, professional, and civic leaders at the Kahler Hotel on February 8, 1956, that the evening edition of the Rochester Post-Bulletin presented the headline, "IBM to Erect Huge Plant Here; 1,500 to be Employed by 1958." A month and a half later, on March 26, 1956, IBM announced Charles J. Lawson, Jr., then assistant general manager of IBM's Poughkeepsie plant, as the general manager of the new IBM facility in Rochester. On the first day of May, contracting firm Industrial Opportunities, Inc. (IOI) began construction for the plant's temporary location. Prior to the completion of the IOI facility, IBM Rochester was briefly located in a former grocery store. Several months later, on August 27, IOI officially presented IBM with keys to the leased facility, which consisted of a 50,000 square foot building with manufacturing areas, offices, educational space, and a cafeteria. Of the 174 IBM Rochester employees at work on this day, 121 had come from the area with the remainder joining from other IBM facilities – a substantial number from IBM's Endicott and Poughkeepsie, New York, locations. The manufacturing knowledge IBM transferred, coupled with the high quality employees it hired locally, allowed the plant to move into production quickly. Just two months after opening the facility, trucks left Rochester for customers in Iowa and Texas carrying the first 077 IBM Numeric Collators manufactured at IBM Rochester.

Unable to lease a suitable building, IBM asked Industrial Opportunities Inc. to build a facility on IOI's planned industrial site in northwest Rochester. IBM leased the building from IOI until its own buildings were completed.



Charles J. Lawson, Jr. was named general manager of IBM Rochester on March 26, 1956. Lawson, who was assistant general manager of IBM's Poughkeepsie, New York, site, came to Rochester to prepare for the establishment of a leased temporary facility and to oversee the myriad of activities associated with building the permanent manufacturing facility.

Thomas Watson, Jr. visited the plant to greet the employees of IBM Rochester at 8:30 in the morning of January 3, 1957. He gave the employees a sense of the tradition that they were becoming a part of, a tradition that had begun with his father and had helped shape industrial theory in the United States. He spoke of his father's background and early and continuing leadership in guiding the firm's success. He spoke of sales schools, of company songs, of THINK signs, of the importance of manufacturing to the organization, and most of all, of the firm's commitment to its employees. He concluded by reminding all IBM managers and employees that, even though the general philosophies that had been key to the firm's successful past would be the guiding force for the company in the future, "40 years from now you won't even know the IBM Company of today, and I think those next 40 years will give everybody all of the opportunity they could hope for to move ahead."

THINK® was a one-word slogan developed by IBM founder Thomas J. Watson, Sr. It appeared in IBM offices, plants, and company publications in the 1920s and in the early 1930s began to take precedence over other slogans in IBM. Watson's motto was used as the name of IBM's employee publication for years and was incorporated into the brand name of IBM's popular notebook computer – the ThinkPad.

As IBM was hitting the ground running in Rochester with its temporary plant leased from IOI, plans were well under way for its permanent facility. In February 1956, IBM announced plans for a 400,000 square foot structure, and ground was broken for IBM Rochester's permanent $8 million building on July 31 of that year. The plant was to be located just off Highway 52 on 397 acres of land that was on the northwestern edge of Rochester. By mid-September, plans were revised to increase the size of the new facility to 552,000 square feet. The first of the buildings constructed was a 60,000 square foot warehouse. By March 1957, the company gradually began to shift some of its personnel, along with assembly and manufacturing equipment, to its permanent facility.

Groundbreaking ceremonies were held on July 31, 1956, at the IBM Rochester construction site. The IBM facility was designed by Eero Saarinen Associates, Inc. The new facility was constructed by Johnson, Drake and Piper as general contractors, with Smith, Hinchman and Grylls serving as consulting engineers.

The formal dedication and open house for the plant was held on September 30, 1958. By that time, the facility was 570,000 square feet, all of which was opened to the public. IBM Rochester General Manager Charles Lawson discussed facts about the facility and its workforce, and outlined how the Rochester operation was an integral part of the manufacturing of IBM's largest division, the Data Processing Division. The facility was dedicated by Thomas Watson, Jr. and Minnesota Governor Orville Freeman. Rochester's Mayor Alex Smetka spoke of the many economic and social benefits that had already begun to be enjoyed as a result of IBM bringing many new people, ideas, and philosophies to Rochester. It was a joyous occasion for both the firm and the city that was celebrated with the accompaniment of the Minneapolis Symphony Orchestra.

IBM Rochester began exclusively as a manufacturing operation assisting the corporation to meet its production goals. Over time, the design of innovative computer systems let the corporation fill a fundamental gap in the market. The story of this change is one of dedication by a wide range of people at the Rochester site. It was a profound and successful attempt to bring value to the corporation. IBM Rochester became a meaningful partner in corporate planning, and over 50 years, helped to change the way IBM developed products. To be sure, other IBM units contributed to this change in important ways, too. Nevertheless, IBM Rochester's significance to the firm has been profound.

IBM Rochester's initial $8 million facility comprised 400,000 square feet of floor space. The city of Rochester is seen in the distance.

On September 30, 1958, more than 25,000 people attended the dedication of IBM Rochester's new site. During the open house, attendees took tours where they learned about parts assembly from manufacturing employees.

A Rochester dairy farmer watches over a herd of cows in 1960, while just south of the farm field, IBM employees are building 25 different information handling products.

Four Phases of IBM Rochester

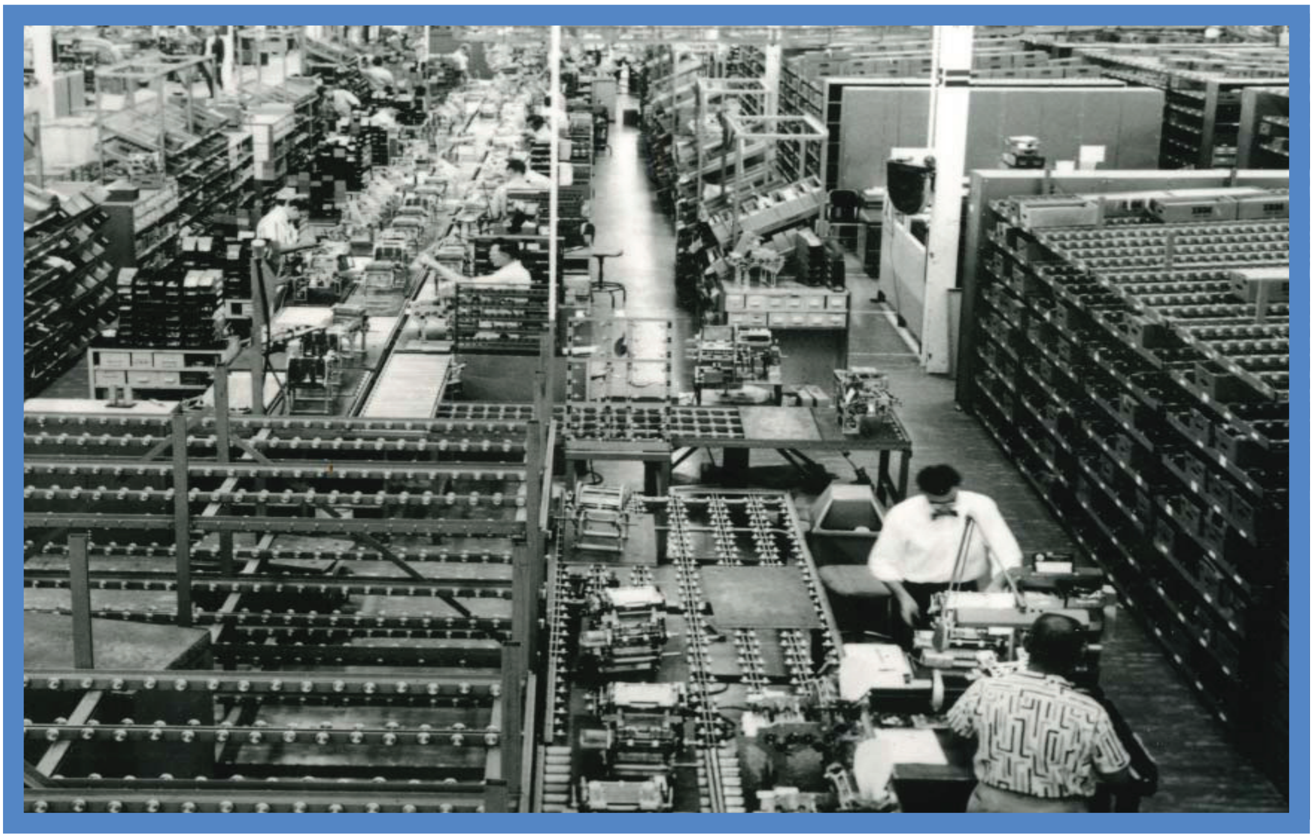
IBM Rochester's history can be seen as a series of four phases. Phase one began naturally enough at the establishment of IBM Rochester. During this phase, the facility served principally as a manufacturing site for punch card products developed around the IBM Corporation. The establishment of the Rochester development laboratory in 1961 led to the accumulation of the knowledge and capability of how to develop products to add to the corporate line. When the laboratory developed their first computer system, the IBM System/3, IBM Rochester entered phase two. In this phase, employees focused on designing a range of computer systems to appeal to various-sized businesses with different needs. Manufacturing of earlier products continued, but it began to change as manufacturing interacted more with the development laboratory. This phase ended in the late 1970s with the move into the design of remarkable new systems: System/38™, System/36™, and the AS/400®, which brought to fruition a new way to design and produce the system and new efficiencies from the use of the systems in business. In phase three, Rochester engineers devised a range of new methods in design, development, manufacturing, and customer interactions. During phase four, in the 1990s and early 2000s, IBM Rochester collaborated with customers bringing new capabilities to customer/IBM partnerships to develop new systems and solutions to solve problems using both IBM and customer capabilities and intellectual property in the process. While the focus was on collaborative innovation through technology wrapped in services, IBM also continued its development of systems, which remained core to its mission.

PHASE I

IBM Rochester's Beginnings: Manufacturing and Modifying Punch Card Machines

At the time of the establishment of IBM Rochester in mid-1956, the most effective information technology storage system in the market was punch cards, although magnetic tape and disks were on the horizon. For example, the IBM RAMAC disk emerged from development in 1956, in a sense sounding the death knell for punch cards. In the beginning, Rochester simply engaged in manufacturing based on specifications for machines supplied by other IBM facilities. Typical of the period was an assembly line with parts inventories on site.

From its beginnings, IBM Rochester participated in developing IBM products to some degree, progressing from small product and manufacturing modifications to the development of major computer systems. The first product manufactured was the IBM 077 Numeric Collator; later the IBM 089 Alphabetic Collator joined the line, both punch card machines were developed in the late 1930s. These were filing machines that arranged cards in the order desired for subsequent operations. The 077 processed cards punched with numerical characters, while the 089 processed punched cards with numerical, alphabetic, or special characters. Within months of the beginning of manufacturing at Rochester, engineers redesigned these systems and began producing the 085 and 087 collators. These functioned in the same manner as the 077 and 089. Indeed, within the facility's first year, it had 10 machines in production, many of which were superseded by redesigned machines over the next two years.



An early, typical assembly line for the manufacture of collators and punches.

The IBM 077 Numeric Collator was IBM Rochester's first manufacturing responsibility. Designed in 1937 at IBM in Endicott, New York, the 077 was a filing machine that arranged punched cards in the order desired of subsequent operations. IBM Rochester's entire workforce is shown with the 077 on August 1956, at the IOI building.

IBM entered the market for bank processing systems in the late 1940s. The IBM 803 was used to sort, list, prove, and endorse checks, sales vouchers and other business documents in a single operation. Containing 32 sorting receptacles, the 803 had a number of compartment adding tapes. A control tape recorded all transactions in the original sequence, with sub and final totals of distributions. The ten-key electrified adding machine keyboard simplified the 803's operation.

The basic operations performed by the collator were selecting specific cards from a file; checking the sequence of cards in a file; combining two files into one complete file, with or without the selection of cards; matching two files of cards by selecting any unmatched cards from each file; and detecting un-punched cards. In the second half of 1957, the IBM 552 Alphabetic Interpreter, designed in 1937, was withdrawn and replaced by the newer IBM 548 Interpreter. In July, IBM announced the 088 Collator. The 088 was capable of handling 650 to 1,300 cards per minute, and it was the first IBM card system to incorporate radial stacking facilities. Two high-speed punches – the IBM 541 and IBM 542 – were announced in January 1957. These punches served as input and output for IBM's 604 and 607 calculators. The systems, which relied on relays and vacuum tubes, processed 200 cards per minute, double the rate of their predecessors.

In March 1959, IBM announced its fastest card reader, the IBM 7500 Reader, along with the new IBM 7550 Punch, would be manufactured at Rochester. The reader and punch were two of 15 units included in IBM's new fully transistorized 7070 Data Processing System developed at Endicott. This reader used printed wiring cards containing tiny transistors, capacitors, resistors, and minute ferrite rings that made up the core memory. IBM Rochester also played a supporting role in manufacturing card systems for IBM's STRETCH computer.

In early 1961, IBM's Poughkeepsie facility transferred several more products to be manufactured at Rochester: the 802, 803, and the 1201 bank proof line. These proof machines consolidated the four principal check-handling operations of sorting, listing, proving, and identifying into one simple operation. Simultaneously, control totals – each accompanied by its individual detail listing – were prepared for as many as 32 separate distributions. Thirteen thousand new machines were built, and 10,000 were reconditioned and returned to service. The 803 was withdrawn in mid-1982 after 33 years of service, from 1949 to 1982. Other machines that were produced included the 1622, an integral part of the 1620 data processing system, the 1203 check inscriber, and the model 188 collator which was designed in the Rochester development laboratory in 1961. Manufacturing acquired new and more complex machine tools such as the Milwaukee-Matic, a tape-controlled machine tool, and a Gardner Denver, a card-controlled, wire wrapping machine. Nevertheless, the production requirements for these unit record machines, added to others already being manufactured at Rochester, resulted in an overload in the plant.

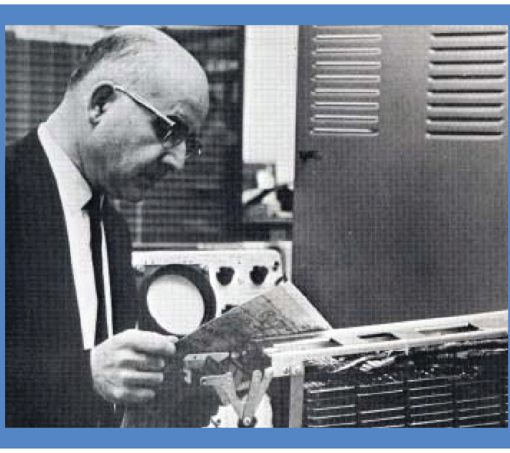
Three factors converged to generate this problem. First, when any product is transferred between plants, the receiving plant has a learning cycle on the new machine which slows production. Second, in this case, IBM Rochester also found a significant number of poor quality components in the inventory for these machines. This further slowed down production as workers found and replaced the bad parts, some of which had made it into assembled machines. Third, IBM experienced greater than expected demand for the machines, especially for the 803 and the 1201. The Data Processing Division asked Rochester to build more machines than planned, which Rochester agreed to do.

To manage and resolve this overload, IBM Rochester increased the direct work force, engaged in some subcontracting, extended the work week in machining temporarily to 60 hours, and obtained services from the IBM plants at Endicott, Kingston, and Poughkeepsie. Another help was the planning for a numerical control program in the early 1960s to develop new methods and procedures. The first numerically-controlled machine went into operation in late 1961. It produced eight difficult-to-machine castings for the new 1203 pre-production machines at a substantial cost savings. The manufacturing engineering group also reevaluated assembly methods to improve production numbers. The overload lasted until spring 1962. No sooner was this problem solved than new products entered the line and a large engineering group was transferred from Endicott to help with the changes. It was not until the end of 1963 that management at IBM Rochester believed they had everything in hand to meet the demands of the corporation and the market for the machines produced at Rochester. Indeed, IBM Rochester positioned itself by promoting new card machines, replacing these designs regularly with improved machines used on various IBM computer and calculator systems developed at other locations.

IBM Rochester Development Laboratory

During its first five years, IBM Rochester served as a manufacturing site, playing only a modest role in the redesign of established unit record punch card equipment. Lawson moved from the general manager position in early 1960, and Clarence E. Frizzell was named general manager of IBM Rochester. Only a year later, Arthur L. Becker became general manager. Becker had been assistant general manager of the General Products Division and had been with IBM for more than 28 years.

The addition of a development laboratory, in June 1961, meant Rochester now had responsibility for the design and development of new products. The integration of the laboratory with manufacturing grew over time, from supplying the manufacturing division with prototypes and letting it decide how to produce the component or system, to an ever-increasing interaction between the units earlier and earlier in the design and development cycle. This collaboration helped to produce better designs and processes and led to greater efficiency and lower costs. Development laboratories in IBM, as in many high-technology firms, were the centers of new product design for their manufacturing facilities to produce. These establishments were distinct from the basic research laboratories such as Yorktown Heights, New York. Some basic research went on in the development laboratories, but it was in support of product or process innovation. Francis F. (Dutch) Fairchild became the first head of the laboratory, coming from Endicott where he had been administrative manager of the development laboratory. A 25-year veteran of IBM, Fairchild joined the firm as a customer engineer in 1936.



Francis F. Fairchild, first manager of IBM Rochester's development lab, looks over diagrams of electric circuitry. In front of him is a gate holding transistorized circuitry used in modern computers such as the IBM 1401.

In 1962, IBM Rochester's first solid-state IBM 188 Collator rolled off the assembly line. Core storage took the place of relays and transistors replaced vacuum tubes.

The IBM 1402 Card Reader-Punch was designed in 1959 as the input unit for the IBM 1401 data processing system. The 1402 was a combination punch and reader with an input capacity of 800 cards per minute and an output of 250 cards per minute. IBM Rochester had responsibility for manufacturing the 1402.

During its first six months of activity, the Rochester development laboratory began development activities directed toward medical electronics, developed and released the 188 Alphanumeric Collator, sent the 1402-2 and 1622 card reader punches into production, and aided with the transfer of the bank proof machines from Poughkeepsie to Rochester. IBM assigned the new laboratory the task of designing the new, transistorized 188 Collator. Core storage replaced relays and transistors replaced vacuum tubes. The collator could process up to 1,300 cards per minute. The 1402 card reader-punch was the input unit for the IBM 1401 data processing system, the first IBM system to have 10,000 installations. It was a combination punch and reader with an input capacity of 800 cards per minute and an output of 250 cards per minute.

On a finer level of detail, the laboratory's product engineering group devoted considerable effort to the redesign of the 1402 punch unit cam and cam followers that reduced cam follower wear by 80 percent, released the carbon graphite contact rolls on the 1402, 1402-2, 088, and 1622, and completed the field merge program between the 1620 and 1622. The materials group of the laboratory assisted in the establishment of the adhesives bonding department and the broadening of adhesive applications, expanded the sintered metal program, developed applications of molded carbon-graphite contact rolls, bonded die and strippers, and incorporated the use of ultrasonic testing for adhesive bonds. The electrical group designed a photoelectric emitter that utilized read switches, the basic logic circuits for the 188 Collator, the photoelectric system for the 1201 proof inscriber, and developed diagnostic techniques for the increased speed punches and the 087 Collator. Many of the fundamental aspects of these activities ended up in a technical report series for use by other IBM sites and subcontracting vendors.

Part of the reason the development laboratory was established at IBM Rochester was to focus on the important problem of alphanumeric readers. IBM already had machines to read numbers. Banks used the IBM 1210 magnetic scanner to read checking account numbers. The IBM 1418 could read magnetic ink text. IBM, however, also wanted equipment that could read bills, receipts, checks, time cards, income tax forms, insurance premiums, deposit slips, and feed this information onto magnetic tape. In other words, IBM wanted to market machines that could read and recognize everything normally put down on paper and processed in volume. The main development problem was the recognition portion of the system; the part that analyzed, evaluated, and sought to

identify printed characters. To pursue this task, the document input/output technical development group, headed by Fred L. Croke, an IBM Rochester employee, pushed to enlarge the group's staff by 28 professional engineers and 21 technical employees by March 1, 1962.

During a 1965 visit to Rochester, IBM Chairman of the Board Thomas J. Watson, Jr. visited with Gary Landon, a test operator for the 1031 Data Collection Terminals.

The first solid-state IBM 188 Collator rolled off the assembly line in 1962, as the new development laboratory's first product. IBM also produced several offerings for use in banks, and the Rochester facility manufactured the IBM 802 and 803 Bank Proof Machines and the IBM 1201 Proof Inscriber, all shipped in 1961. In 1963, IBM Rochester announced its first two complete systems for this line: the IBM 1060 and IBM 1030. The IBM 1060 enabled a teller to locate customer information stored in an IBM 1440 Data Processing System, process it, and print the results at the bank teller's window in seconds. The IBM 1030 Data Collection System featured a pocket-sized recording device enabling employees to gather production information and transmit the data over communication lines to a computer in the same building or thousands of miles away. A new card reader and punch appeared in 1965 – the IBM 2540. It could read as many as 1,000 cards per minute and punch at speeds up to 300 cards per minute.

Moving into a new application area, IBM Rochester, in cooperation with Saint Marys Hospital and Mayo Clinic, designed and manufactured the IBM Surgical Monitoring System, which collected data on a patient's venous blood pressure, respiration pressure, electrocardiogram (EKG), and electroencephalogram (EEG). This monitoring system gave medical teams more complete and accurate information on the condition of a patient during surgery than had previously been available and reduced the number of people needed on the operating team.

Over the next few years, a series of new card readers, punches, data transmission terminals, and optical readers came off the IBM Rochester manufacturing lines. For example, the computer trade magazine *Datamation* noted in July 1969:

> *The most popular hand printed character reader by far today is the IBM 1287 document reader. This is a curve tracing reader, which follows the outline of the hand printed numeral with a small circular scan. If the trace formed by the character fits into the normal tolerance pattern for a particular character, then the machine will identify it correctly. This technique permits a rather wide variation in hand printed numerals.*

The IBM 1287 Optical Reader, designed in 1966, manufactured at Rochester, and first delivered in 1968, was the first scanner capable of reading handwritten numbers. Information written by sales and delivery personnel and receiving clerks could be directly entered into a computer system for processing. The 1287 also read machine-printed credit card numbers and cash register rolls.

In the fall of 1966, some 30,000 visitors toured IBM Rochester, marking the tenth anniversary of the facility. Here a group of nuns from a local religious institution and other women heard descriptions of parts used in the manufacture of IBM computer systems.

In 1968, Rochester IBMers gathered around the 100th IBM 1287 Optical Reader scheduled for shipment to an IBM customer.

In the next two years, the laboratory expanded its range of activities to include document handling development, including character sensing technology – magnetic and optical readers – and paper handling; and product engineering – the IBM 1013 card transmission terminal, the IBM 1442 card-reader punch, the 1202 unit inscriber, and the redesigned 1201 proof inscriber. The laboratory also successfully engaged in engineering analysis – including industrial design, human factors considerations, printer parts, special systems engineering, terminal development, application developments, such as molded plastic parts, adhesive bonded units, plating processes, and patent operations. The concentration on card machines continued into the 1970s.

Achieving Greater Innovation in Manufacturing

In addition to the increasingly impressive work coming from the IBM Rochester development laboratory, the manufacturing side also evolved to achieve substantial levels of innovation for the Rochester site and the overall company. This was evident on both the product and process side. Early in IBM Rochester's history, its prototype manufacturing group contributed significantly to developing innovative designs and redesigns of components. IBM Rochester had a full machine shop and production facilities, including extensive heat treatment and plating capabilities.

IBM's prototype work also built capabilities in areas where the site would play an increasingly greater role for the corporation, particularly in the disk drive field. In the 1960s, IBM Rochester built prototype disk drive components for IBM San Jose; in particular, it built a number of hydraulic actuators for the 24-inch and 14-inch disk drives. A clean room environment was built at IBM Rochester – including sticky floors, air turn over, and the required use of masks – to assemble and test disk drives for San Jose. By the late 1960s, a substantial amount of the hard disk drive work moved to Rochester because of the successful prototype manufacturing done earlier in the decade.

IBM gained strong synergies and efficiencies through the interaction between manufacturing and the development laboratory of the site. One IBM manufacturing employee of this period, Tom Paske, a central Minnesota native who began as a prototype parts machinist right out of high school in 1961 and later became involved with strategic sourcing, acquisitions, and divestitures prior to retiring in 2005, stated with regard to the relationship of manufacturing and the laboratory in the 1960s and 1970s:

> *The manufacturing arm and the engineering arm worked very closely together. The facilities…were joined together with a hallway, so all you had to do was walk down the hallway and you could talk to the person who was in charge of a part. It made it easier for the manufacturing engineers and the development engineers who were working on it – plus you had the prototype facilities, because you primarily made it right here. The relationship started early… Many times on the release of a new product, they would actually set up a complete early manufacturing department that would work directly with the development group to take the product out of the development laboratory and bring it into production… It started a model of how things operated later on, when people started talking about early manufacturing involvement.*

Another element that helped to create a cooperative environment between manufacturing and the laboratory was the overall culture of the site. Many employees, like Tom Paske, spent their entire career at IBM Rochester. Of course, some left for opportunities in San Jose, Austin, Boulder, New York, and other IBM sites around the country and around the world. Nevertheless, a number of employees who had attractive opportunities to leave, chose to stay in Rochester. This helped contribute to creating a relatively close-knit facility for its size, but also, at times, presented challenges for the corporation – when IBM wanted to take advantage of a Rochester employee's knowledge elsewhere within the firm. Many employees were from Minnesota and wanted to stay, while others came from other locations and quickly became attached to the city of Rochester, its excellent schools, and its attractive environment for raising a family. IBM Rochester's positive corporate culture was characterized by an atmosphere of cooperation and collaboration at the facility.

In addition to being innovative in the 1960s and beyond on prototype development and product engineering, IBM Rochester was also innovative in manufacturing processes. At the start of the 1960s, the facility instituted a "parts supermarket" to handle some of the movement of parts by using conveyer lines and automated equipment. In short, there was a significant investment in materials handling automation. With the greater ease of assembling products achieved during the 1980s, it became easier and more efficient to convert to an advanced materials handling system coupled with manual assembly stations. During the same period, IBM Rochester was also converting to become a "paperless factory." Utilizing computers extensively on the shop floor became an important mechanism to eliminate, or at least tremendously reduce, the amount of paperwork associated with building more and more machines (especially the midrange computers) that were made to order.

In many respects, the paperless factory was representative of the broader changes that had been occurring at Rochester and other IBM sites, leading to greater efficiency and flexibility in manufacturing, and at the same time, higher employee satisfaction and more effective career development. In 1972, IBM Rochester initiated a program of job enrichment applications and soon followed this with job design principles to help develop and

integrate employee skills. In the late 1980s, a formalized, more extensive corporate plan was developed by IBM manufacturing leaders meeting in Armonk. This resulted in IBM Rochester's solidification and extension of procedures and practices in manufacturing to improve efficiency and flexibility. This was implemented at different facilities under different names in the succeeding few years. At IBM Rochester it became Manufacturing Skills Integration (MSI).

MSI, implemented in the early 1990s, enabled IBM Rochester to use its talent in manufacturing to the fullest. It responded to both the emphasis from IBM's late 1980s push, as well as to Rochester manufacturing's long-term emphasis to provide shop floor personnel with more variety and greater flexibility in their jobs. IBM's Circuit Package Production Center and the 3.5-inch hard file areas were among the first at the site to integrate MSI into work processes. Changes involved placing less emphasis on functional-based organization – including production, quality control, maintenance, and manufacturing engineering – in favor of shifting these previously separate support activities to production areas. In other words, "moving tasks to people, not people to tasks" as Ev Ellenwood, Rochester's MSI coordinator explained in 1990 in IBM Rochester News. Under MSI, IBM production workers took on a number of maintenance tasks, leading to greater efficiency, worker empowerment, a more varied and fulfilling job experience, and the expansion of technical expertise, problem solving, and career advancement opportunities.

Improvement in reducing waste of any kind in the production process was an increasing focus of the firm's manufacturing management in the mid-to-late 1980s and throughout the 1990s. Over this time span, the facility made increasing use of expert systems, statistical process control, and continuous flow manufacturing (CFM) techniques. In 1982, IBM Rochester hosted the first Statistical Quality Control conference of its kind within the corporation, and it continued to provide leadership in implementing quality processes following this event. Continuous flow processes were in place within some departments by the mid-1980s, including slider engineering and manufacturing, the circuit-package production center, head manufacturing and the 5362 assembly line. There was some initial resistance, but employees quickly embraced CFM, leading to its success. As John Costello, CFM coordinator for Storage Products stated in 1985, "People are the key ingredient to CFM because responsibilities, processes, and work relationships change; flexibility and a willingness to accept a new way of doing things is becoming a way a life." Continuous flow processes further added to quality inside IBM Rochester, and increasingly, throughout the supply chain. IBM Rochester engineers subsequently helped many suppliers develop and extend their CFM capabilities to ensure overall quality and efficiency.

PHASE II

IBMSystem/3

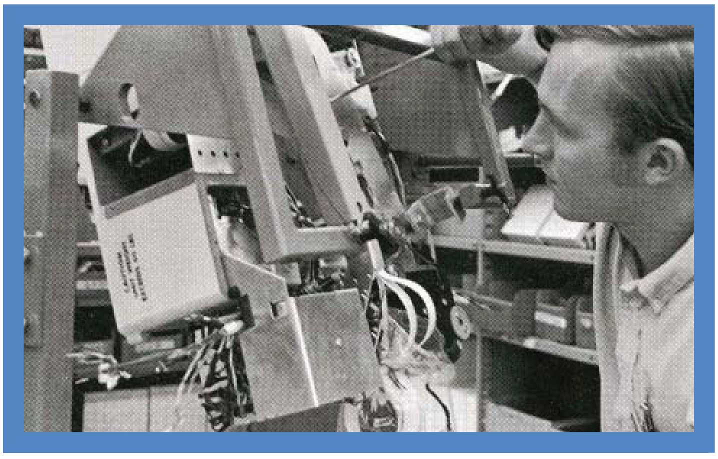
When IBM searched for a new small- to medium-sized computer system for business, Rochester received permission to go ahead with a design. IBM Rochester would develop the IBM System/3, that along with its progeny, made up what became known as midrange systems. These were the electronic digital computers that would eliminate the market for traditional unit record equipment and replace it with lucrative new products that were more powerful and had greater flexibility. These systems would in turn have a profound impact on government, commercial, and institutional computer-based data processing in the last quarter of the twentieth century and into the twenty-first century.

With the leap into the design of System/3, Rochester ended its first phase of activity: design and manufacture of unit record machines. During the decade after its creation, IBM Rochester demonstrated its prowess in manufacturing by producing some 50 different machine products, built an in-house knowledge of computer design in a period when computer design was undergoing rapid change, and moved from a focus on machines to

concerns for customers' overall needs. Rochester did not abandon its interest in storage and handling of data as it would go on to participate in the disk storage development area. The second period of IBM Rochester's evolution would see a move from design of complete systems inside Rochester to a revamping of the design process to examine every stage of development, production, and use, partnering with users as the new product design evolved.

The IBM System/3 was designed by the Advanced Unit Record Systems group, even though this system had computer capability. The group was led by Harry Tashjian. Tashjian joined IBM in 1948, and in 1959 he moved to IBM Rochester to direct the development of the 188 Solid State Collator. After the 188 appeared in 1962, he turned to the development of other machines, and in the middle of the decade, he led the System/3 project. The announcement of the System/3, in July 1969, referred to nine new units, of which three bore the following designations: 5410 Processing Unit, 5424 Multi-function Card Unit (MFCU), and 5203 Printer. Provision for compact disk drives was the final touch that made System/3 Model 10 a flexible and expandable system. A 5444 Disk Storage Drive that fit into a drawer beneath the MFCU could provide online direct-access storage of approximately five megabytes (MB). The drive's spindle accommodated two disks; the lower was attached permanently and the upper was removable and interchangeable. The access head had four read-write heads, one for each surface of the disks. Two 5444 units could be ordered, giving the system a total capacity of nearly 1.25 MB.

IBM introduced its IBM System/3 computer (IBM 5410) on July 30, 1969, to meet the computing needs of small businesses. It was the first system totally developed by the company's laboratory in Rochester, Minnesota, and the most significant IBM product announcement since the IBM System/360 in 1964. It featured a smaller punch card which could encode up to 96 characters per card. The System/3 used IBM's new monolithic integrated circuits.

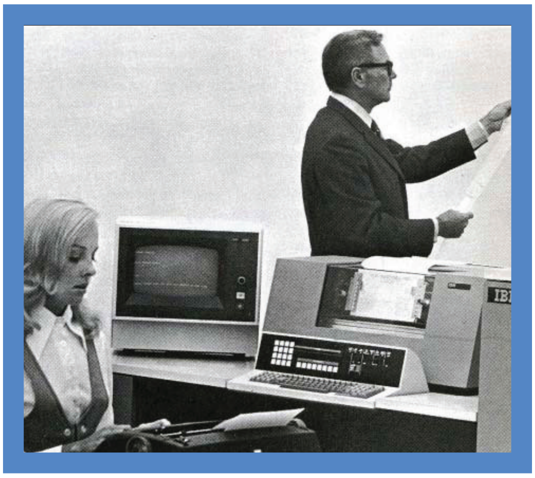


During final assembly, IBMer Rick Pille makes mechanical adjustments on the 5444 disk storage file.

System/3 was a cross between a punch card system plus calculator and a computer with various types of storage, including punch cards. Its design acknowledged that small- and medium-business users relied on punch cards for Input/Output (I/O) storage. The size of these businesses made it too costly to move to a larger computer system such as the IBM 1401 or the IBM 7090. So to ease the transition, the new System/3 allowed them to retain their reliance on cards and achieve added computing capability at an affordable price. The System/3 utilized a mere 28 instructions, most of which operated on data in memory. Instructions processed one byte at a time. Memory capacity was modular, ranging from eight kilobytes (KB) to 32 KB. More than 1,500 low-cost System/3 Model 10s, IBM's first model in the series, were installed in the first full year on the market. The Model 6, introduced in 1970, had the added ability to process standard ledger cards and switch easily from business applications to complex mathematical problem solving.

Innovations associated with System/3 included a redesigned smaller punch card, one-third the size of the traditional card, the first redesign in 40 years. This substantially smaller card nevertheless held two percent more data. Larry Wilson, an IBM Fellow in San Jose who originally designed the 96-column card, was invited to Rochester to incorporate the card into the System/3. Per unit of area, the new card's information capacity was more than three times that of IBM's traditional 80-column card. Engineers also used a new IBM-developed semiconductor system, Monolithic Systems Technology (MST), which incorporated more minute electronic components than any previous technology available. The use of MST circuits led to a remarkably compact and capable processing unit. MST circuits also were used in the multifunction card unit, which had been scaled down in size to suit the proportions of the small card. Solid Logic Dense (SLD) circuits, tightly packed versions of Solid Logic Technology (SLT), were used in other units of the system. Rochester programmers enhanced IBM's Report Program Generator (RPG) for use as a programming system, calling it RPG II.

The original version of RPG was an unusual programming language designed for use with the standard 80-column card used with the IBM 1401. It was important for the 1401 family as well as for a subsequent generation of machines starting with the System/3. RPG was developed to ensure that programming would not be an obstacle in the market for 1401s. It facilitated the preparation of programs that wrote reports. These reports were prepared from data stored on punched cards, disks, or magnetic tape, and were a regular feature of plugboard use in electronic accounting machines. Instead of writing a specific program for each required report, the user only needed to specify a description of the data from which the report was to be made and a description of the format for the desired report. These specifications were written in terms that required little knowledge of machine language coding. The RPG processed the specifications using a translating program that converted the specifications to ones readable by a 1401, which then produced a program that created the desired report. RPG simulated the plugboard wiring of earlier calculator systems and was an easy way to program a business application without extensive effort. RPG II was developed for the 96-column card. A variety of generalized application programs that could be tailored to local needs by specifying parameter values were provided as well.



The low-cost System/3 Model 6 was designed for use by just about anyone who worked in an office.

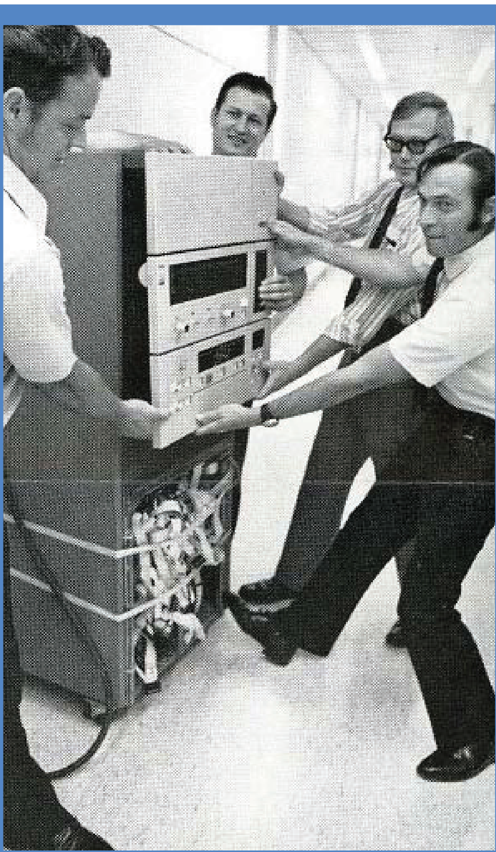
In designing System/3, engineers at Rochester followed, by this time, a traditional computer industry development cycle: hardware, software, and testing, in this order. They allotted essentially no role to the user. The computer system was designed by the engineers and presented to the customer for whatever use the customer could make of it. In the early years, often only a few applications existed at delivery. Over time, many new applications were developed.

As an example of business use of the System/3, The Meyer Broadcasting Company of Bismarck, North Dakota, installed an IBM System/3 Model 6 in 1972. The company owned three TV stations, three FM radio stations, and two AM stations, and employed 140 people. They wanted the computer installation to increase the accuracy and quality of data for programming and scheduling. The computer's primary purpose was to schedule commercials for both radio and TV. As historian James Cortada pointed out in his multivolume study of industry uses of computers, *The Digital Hand*, the company could rotate advertisements quickly and accurately around its stations and track what was sold, broadcast, and billed. The company employed the system in ways that are more traditional as well, for accounts receivable, general ledger, payroll, accounts payable, cable TV billing, product analysis, and sales analysis. It was such successful uses of System/3 in small businesses that allowed IBM to sell or lease some 25,000 System/3s in the lifetime of the system. This was a completely new business opportunity for IBM. The development and production of System/3 is a sterling example of the capability of several IBM sites working closely to integrate a system with great capabilities at a reasonable price. Development of the hard disk drives, the printer, the tape drives, the keyboard, and the MST logic components all occurred at sites other than Rochester.

The second IBM System/3, the Model 15, made its appearance in July 1973. The Model 15 filled the IBM product gap in the marketplace between the smallest System/370™, the Model 115, and the System/3 Model 10. The Model 8 joined the System/3 family in September 1973. The newest member of IBM's most popular computer family to date met the needs of potential customers in a wide variety of businesses through a compact, low-cost flexible system. Announced jointly by IBM Rochester and IBM Boca Raton, Florida, the Model 8 was a cardless, disk-oriented computer using existing system control programming.

C.B. (Jack) Rogers, Jr., president, General Systems Division, tries out the 3277 display station and keyboard of the new System/3 Model 15 during an inspection of the system on July 10, 1973, the day IBM announced the enlarged system. On the right are Dean McKay and John Opel, IBM senior vice presidents and Data Processing Group executives. On the left is Harry Tashjian, systems manager, General Purpose Systems (GPS) – the Rochester Group which developed the Model 15.

Because the System/3 was new business for IBM, aimed at customers who did not fit IBM's traditional customer profile, a decision was made in November 1969 to form a new division. The new division, the General Systems Division (GSD), IBM's first totally integrated division, had the responsibility to design, develop, and manufacture the new systems. It also had responsibility in the United States to market and service these products. The new alignment gave IBM Rochester a singularity of purpose: the GSD center of development for its low-cost general purpose systems and their programming and sales support. In July 1971, IBM Rochester was realigned and established as the General Systems Division Center for General Purpose systems. The first units developed at Rochester under the newly established GSD were two card-handling units, the 3505 card reader and the 3525 card punch. These units, enhancements to IBM's System/370 Model 135, along with System/3, were the first Rochester products to use the new Monolithic System Technology.



In September 1973, Rochester's "old reliable" went into retirement. One of the first System/3 machines ever built was shut down for the last time. Its meter showed 15,378 hours of use, more than any other system in existence at the time.

While developing the various models of System/3, IBM Rochester was active on other systems as well. In January 1973, IBM Rochester delivered another successful design: the IBM 3740 Data Entry System, which was received enthusiastically by customers from coast-to-coast. The 3740 came with another new development in the IBM 3540 Diskette Input/Output Unit. The two were versatile new machines for entering business data into a computer.

In another new direction, in September 1975, Rochester introduced the IBM 5100 Portable Computer. The 5100 weighed approximately 55 pounds and it was sized slightly larger than an IBM typewriter. The Portable Computer was intended to put computer capabilities at the fingertips of engineers, analysts, statisticians, and other problem solvers. Twelve models provided 16 to 64 KB of main storage, which came with either or both APL or BASIC programming languages. IBM offered three Problem-Solver Libraries, contained in magnetic tape cartridges with the 5100 to provide more than 100 interactive routines applicable to mathematical problems, statistical techniques, and financial analyses. The 5100 was withdrawn from the market after the IBM PC was introduced.

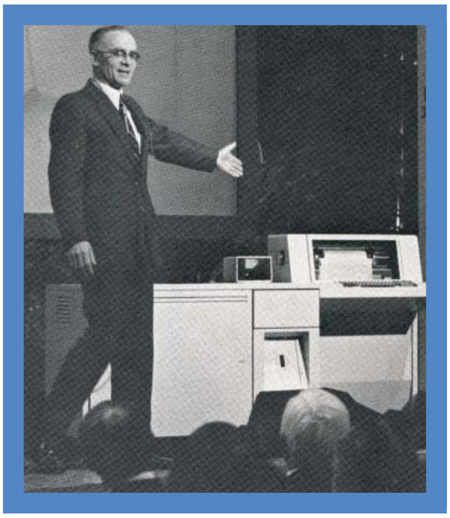
Rochester's emphasis on new machine designs stimulated a rearrangement of manufacturing within the corporation and the end of an era at Rochester in 1978: manufacturing of IBM's card readers and punches was transferred to IBM Toronto. These included the readers and punches for the System/360, System 370, System/3, and flexible disk transmission terminals for the 3740 Data Entry System. At the time, 12 percent of all general purpose systems in use were IBM System/3 Model 10s, and over 18 percent of all small business computer systems in use were IBM System/32s.

In 1975, IBM Rochester shipped the first Rochester-developed IBM 5100 portable computer – a desktop computer introduced six years before the IBM PC. Portable may have been a bit of a bold assertion as the 5100 weighed 55 pounds and was the size of a small suitcase.

IBM System/32

After the System/3 appeared, IBM Rochester, with the endorsement of the corporation, exploded with an array of new midrange computer systems for business. System/3 had been introduced in mid-1969, and in the succeeding decade, a number of new models designed for different business settings appeared. In the early 1970s, development activities for business system software were being pursued at Boca Raton and Rochester and in hardware at Rochester as well. Glenn Henry and his group in Boca Raton suggested several ways to incorporate new design procedures for these systems both to advance functionality and to reduce programmer time in using the system. Since the Rochester development laboratory was a focus of new activity for the General Systems Division, Henry moved to Rochester and assumed responsibility for the development of software for a low-end System/3. Originally, IBM was going to call this new computer the System/3 Model 2, but then changed its name to the System/32 when it was introduced in January 1975.

The IBM System/32 was designed specifically to meet the needs of small businesses. It was the first system to incorporate hardware and comprehensive application software. The System/32 was supported by Industry Application Programs for the construction, wholesale paper and office products, wholesale food, hospital, and membership organizations and association industries. The system consisted of a central processing unit (IBM 5320), memory, disk storage, a diskette data read/write facility, and an operator console with visual display screen, keyboard and print capability – all in a single desk-sized unit. IBM Rochester developed and manufactured the System/32 which was announced in 1975.



The System/32 announcement day was held in IBM Rochester's cafeteria in 1975.

The IBM System/32 was an operator-oriented, desk-size data processing system. The system had an operator console through which the operator entered data to the system, controlled the operation of the system, and communicated with the system program. Programs and data files resided on a non-removable disk. Diskettes, which were removable, served as a load/dump medium for creating backup files from information on the disk, as a data interchange medium for exchanging data with other systems, and as a medium for off-line preparation of data and programs. The system operated under control of programs stored in main storage and under control of a microprocessor. The microprocessor served as a control unit and assisted in control of system input and output functions. The microprocessor had a dedicated storage area called control storage. Programming was accomplished by using the System Control Programming (SCP) and came with extensive applications. There were 32 models of System/32, depending on type and speed of printer and disk storage capacity. With various models, a business could also attach an IBM 5321 Magnetic Card Unit, providing additional input/output capabilities and an IBM 1255 Magnetic Character Reader for reading encoded documents.

IBM System/34

IBM Rochester was determined to design and build a new system to follow System/32. System/34 signaled a new era in small computers. This was the era when computing was being wrenched out of the hands of the mainframe guardians and placed in the hands of a broad base of business users. In the mid-1970s, IBM was working to meet the needs of the "naïve" customer, one who had not had any training or experience with computer systems but needed the power the computers offered. System/34 brought a new set of customers to IBM, as it was used primarily by manufacturing, distribution, and construction industries, typically for billing, accounts receivable, payroll, inventory control, and general accounting. The System/34 was a small commercial system unique in a number of ways. Compared to its predecessors, the system could support multiple concurrent users and incorporated many features that set new standards of user-friendliness. This use of communications provided a substantial shift in user opportunities.

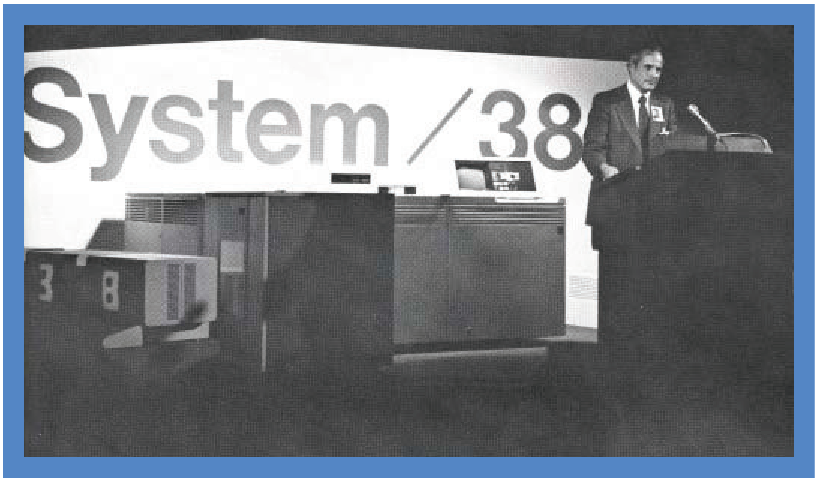
Introduced in 1977, System/34 was a general-purpose data processing system designed for a wide range of applications, such as billing, order writing, and payroll. The System/34 could be used in a centralized or distributed processing fashion. It was an interactive system, rather than a batch system, using four communication lines. The system could run more than one program at a time due to its multi-programming feature. It could use up to 16 IBM 5250 workstations, had a 257 MB disk storage capacity, and 256 KB in its main storage. The 5250 workstation, also developed at IBM Rochester, employed a green Cathode Ray Tube (CRT) screen. The System/34 was one of the first systems with an interactive design, remote workstations, and a diskette magazine. An IBM 1255 Magnetic Character Reader could also be used with this system, and remote data from the IBM 5260 Retail System, described below, could be attached. In 1978, significant software and hardware enhancements to the system support program of System/34 were announced. These included an interactive communications feature (SSP-ICF), COBOL programming language, workstation support subroutine (a programming RPQ), and enhancements to the System Support Program (SSP), Utilities, RPGII, and Assembler. System/34s could now interactively communicate with System/3 Model 15s, System/370s, and other System/34s. System Support Program enhancements included additional system security, a system measurement facility, more operator assistance, and additional 1255 support.

System/34 could not have grown architecturally across a broader range of capacity and price, and there were other desired functions it could not support. Even so, sales indicated that the system had a strong following in the marketplace. To satisfy the market more effectively, IBM Rochester wanted a product that would cost less to produce, incorporate significant new functionality and establish new levels of quality and usability, thus making it more competitive. The search for such a new product led to some new directions in architectural design and cooperation among units in development and production.

The IBM System/34, announced in April 1977, was a low-cost approach to distributive data processing for businesses of all sizes. Centered on the IBM 5340 system unit, the System/34 used as many as eight workstations to provide timely access to current data and offered seven attachments, including the IBM 5251 Display Station. System/34 was designed and developed at IBM Rochester as a powerful multiple workstation disk system, which allowed users to execute programs concurrently with other batch or workstation oriented programs.

IBM System/38

IBM Rochester set a new pace in design work, involved users at early stages in the design process, and leveraged Rochester's and the broader company's capabilities to utilize more common parts and make machines more compatible. In order to understand the origins of the System/38 computer system project, it is necessary to examine a corporate-wide activity at the turn of the 1970s called Future Systems. Noting that a number of new architectural concepts in systems and programming existed, which could have a profound effect on the design of future systems, the Corporate Technical Committee in 1969 recommended development of a coordinated plan to advance IBM's interests in design. By August 1971, a task force was in operation to consider how such a plan could come about. Several proposals showed promise: single-level store, redefined roles for hardware, microcode, and software; object-oriented addressing; capability architecture to provide a high level of security; layered architecture; and layered software. Consensus on how to accomplish a design with all of these concepts as components was difficult to achieve. Between 1971 and 1975, several proposals to modify plans for Future Systems emerged, but a reasonable, cost-effective plan always eluded the designers. The project was just too large and therefore too difficult.



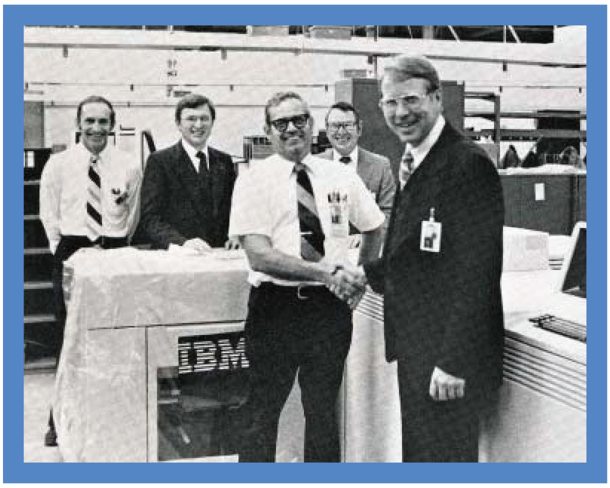
Rochester General Manager Hal Martin hosted the System/38 announcement day activities in the cafeteria on October 24, 1978.

This goal of starting with a clean sheet of paper for design became a focus of Glenn Henry's thinking as he was working on the System/32. When he came to Rochester in 1973, he promoted the idea strongly. Over the preceding few years, a separate group at Rochester also considered new ways to institute new concepts into the design of systems. In the late 1960s, Frank Soltis, as he later reported, was working on an idea for a computer system to follow System/3. In December 1969, he was asked to show his concept to the management of the development laboratory. The following month, management, led by Harry Tashjian, who was now the laboratory director, approved the project to design such a system. This system would become the System/38. For the next 18 months or so, Soltis, Roy Hoffman, and Dick Bains developed the concept for this system. Hoffman was an engineer with considerable experience in computer architectures and operating system designs. He had been working in the Optical Character Recognition (OCR) area. Before coming to IBM, Dick Bains had developed some leading-edge applications and had experience with the Burroughs B5500, which was a high-level machine used at the University of Wisconsin-Madison. He also had a strong background in programming languages and compilers. The three men formed a natural alliance.

A number of people at Rochester followed the deliberations of the Future Systems group. Indeed, there were consultations with the Future Systems group at several points, but the Rochester technical people kept a low profile as they proceeded with their own planning. By the middle of 1972, the Rochester proposal had moved up the chain of approval and new staff was assigned to the project. When it was clear that the Future Systems

On October 24, 1978, IBM introduced the IBM System/38. The hardware and programming innovations of the System/38 permitted many functions associated with large computers to be combined into a compact system. It incorporated many advanced features, including a single-level store, object-oriented addressing, and a high-level machine interface to the user. The System/38 was developed over eight years by IBM Rochester's development lab, and it was manufactured both in Rochester and in Vimercate, Italy. Deliveries of the new system began in 1980.

group would not achieve its aims, Rochester was given permission in August 1973 to launch a full-scale project on a new business system. The new Rochester project adopted many of the Future Systems design concepts. Rochester was able to develop a successful design because of the smaller scale of their design and the limited requirements of the customers for whom the computer system was intended. After the launching of the System/32, Glenn Henry joined this group.



The first System/38 is shipped from Rochester.

System/38, unveiled in October 1978, after eight years of effort, was a general purpose data processing system designed to provide a high-level of function, ease-of-use, reliability, serviceability, and non-disruptive growth. It supported advanced database and interactive workstation applications as well as traditional batch applications. These extensive capabilities were made possible by the use of novel architecture and design concepts, advanced technologies, and new implementation of system components, both hardware and software. The new concepts included a layered structure providing consistent interfaces, a unique high-level machine architecture, and powerful capabilities for virtual addressing and task management. Most customers purchased the System/38 as a regional node in a distributed processing network, a circumstance that gained much favor in the 1970s.

Glenn Henry's team designed and developed System/38's High Level Interface that permitted significant advances in integrity, security, ease-of-use, database and storage management, multi-programming, and language development. Henry took responsibility for directing work that resulted in the actual product, including participating in the entire design process, making key technical and trade-off decisions, and insuring the integrity of the total system.

IBM introduced a number of System/38 communications, hardware, and programming enhancements in early 1981. It produced new communications capability that allowed the System/38 to communicate with most IBM computers and terminals via ordinary telephone lines. Binary Synchronous communications support allowed communication with other System/38s, as well as IBM's Systems/3, 32, 34, Series/1, 5110/5120, System/370 and the 3000 and 4300 series of computers. It also supported communications with the IBM 3741, 5230, 5280, and 5260 terminals. The General Systems Division announced that up to 80 IBM 5250 workstations could now be directly attached to a System/38. Other enhancements involved programming aids to enhance the utilities available and the capability to attach two printers. The announcement of more enhancements appeared over the course of the next year.

One example of an effective use of a System/38 was at the 361-bed Hackley Hospital in Muskegon, Michigan, which adopted the System/38 Model 40 (5382) in late 1984. The hospital previously used a System/34. Doctors' notes were entered without the intercession of a nurse transcribing handwritten text, orders for patient tests and prescriptions were transmitted online, and medical records and accounts receivable used the system to simplify operations and record more details. More than 100 terminals and 60 printers were attached to the System/34 over five communication lines, making the system slow to a crawl. The new System/38 Model 40 had substantially more memory and a better communications facility, thereby allowing the hospital, as well as other users, to upgrade their service.

Mining IBM Research and the Integration of New Products: Disk Drives

By 1978, there were so many opportunities for projects in the development laboratory, management needed to establish some priorities. Demands of the IBM Corporation on Rochester's planning served as guidelines for these priorities. For example, a disk storage mission replaced earlier products. Rochester's hard disk file mission began in early 1977.

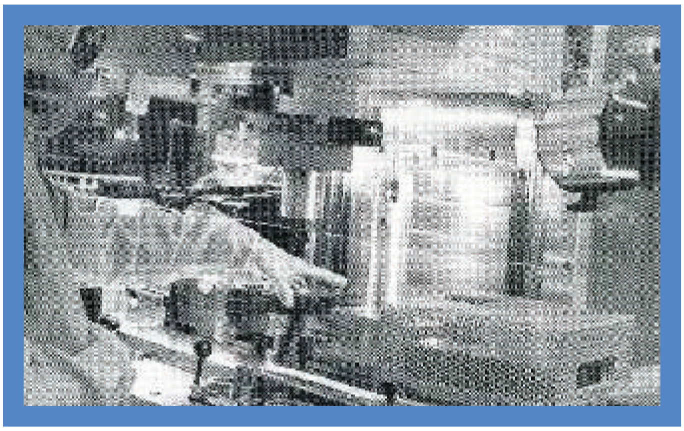
The laboratory addressed a continuing demand for lower cost and higher performance systems by small business. In development, manufacturing, and site support functions, IBM Rochester engaged in new ways of doing business to achieve high quality, lower cost products, while incorporating new technologies on aggressive schedules, when developing new products and enhancing existing products.

By this time, one area of product development and component manufacturing that had become intertwined, in part, with the midrange line of computers, but also existed to serve the corporation and its base of customers of other systems as well, had grown substantially in IBM Rochester, namely disk drives. IBM Rochester followed up on its early work producing prototype actuators for IBM San Jose with manufacturing of some hard disk drives, including 14-inch Gulliver drives, and later, eight-inch Piccolo drives. IBM Rochester manufactured integrated drives for new midrange systems developed at the Rochester lab in the 1970s. Early on, the sharing of expertise between Rochester engineers and technicians and those at San Jose proved critical in expanding capabilities. In the late 1970s, 40 or 50 engineers from IBM Rochester went to San Jose for about half a year to learn more about disk drive research, development, and manufacturing. Other key personnel continued operations and development work at Rochester.

In the late 1970s, the Rochester product development team was working on Star, a 14-inch drive and Spartan and Delphi – both eight-inch drives. Star was based in part on Gulliver, while Spartan was an outgrowth of Piccolo. The storage or disk drive operation of the facility was organized with a recording subsystems group separate from the disk drive development group. There was also a test development operation, which was a large group, in part, because the site was building up its own equipment internally – granite slab testers and other equipment to do high precision testing.

IBM Rochester played a substantial role in the design, development, and manufacturing of disk drives, including drives for the midrange systems produced in Rochester. Pictured here are 5-1/4 inch disks, the first thin film disks manufactured in IBM.

By taking a major role in the storage/disk drive area for IBM, the Rochester team worked with other IBM disk drive operations in San Jose; Hursley, England; Mainz, Germany; and Fujisawa, Japan. By integrating, developing and manufacturing most key components necessary to build complete drives, the site developed very strong expertise and capabilities in the disk drive area. This led to the development of the first Partial Response Maximum Likelihood (PRML) channels and thin film disks to be used in IBM disk drive products. IBM Rochester leveraged this base and took on the challenging task of converting into products some of the strong innovations from IBM Research; especially discoveries in the storage field made at the IBM Almaden Research Center in San Jose. A unique technology transfer organization called the Compact Storage Lab (CSL) was set up with personnel from Rochester and the Almaden Research Center. This led to the integration and first shipment of the IBM Research magneto resistive (MR) head in an IBM product that was developed and manufactured in Rochester. Like many areas of technological innovation, Rochester benefited from the retention of key technical and managerial leaders, either directly in the storage division, or at least, within the site.



IBU (Independent Business Unit) expands the DASD line as the 5-1/4 inch PIXIE file comes to life.

Another strategy that helped IBM Rochester is that part of the disk drive business was set up as an Independent Business Unit (IBU) within the storage group at the facility. It was important, especially in the early years of the business, to address the fact that competition was generally weak. This, however, changed as disk drives moved toward standard size form factors and more large firms, such as Western Digital and Seagate Technology, Inc., entered the business and grew rapidly.

The continuity provided by a stable, highly skilled staff that existed in the 1970s and 1980s, began to change in the 1990s in line with broader IBM changes in response to the increasingly competitive global marketplace. This had a particularly dramatic impact on the Rochester storage group. In the early 1990s,

IBM reorganized, largely along technological areas, and Rochester's storage business joined forces with storage operations being conducted in San Jose, Hursley, Mainz, and Fujisawa. Collaborative work with these facilities had long occurred, including a major project to transfer disk drive development and manufacturing knowledge to Fujisawa. The reorganization meant that all hard disk file manufacturing was taken out of Rochester, leaving disk manufacturing in place. Responsibilities for product development and release to manufacturing were placed with San Jose and Fujisawa. Costs were high in San Jose, and a new lower cost operation in storage was soon established in Singapore.

In the words of Jim Licari, the head of Rochester disk drive operations after the downsizing, IBM Rochester was "left with significant technical work, but became part of the 'development pie' in the storage area." The new development group released new disk drive products with advanced interfaces into manufacturing in Fujisawa, Japan. When the staff in the storage area was significantly reduced, other disk drive competitors benefited from hiring skilled IBM and former IBM employees to grow their facilities in Rochester and in the Minneapolis-St. Paul metropolitan area. In 2003, following IBM's strategy of getting out of commodity businesses with small and diminishing margins, IBM sold its disk drive business to Hitachi. Hitachi combined and integrated it with its existing storage business to form Hitachi Global Storage Technologies, a firm headquartered in San Jose that conducts part of its operations out of space leased at IBM Rochester.

Innovating Retailing Data Processing: IBM 5265, IBM 5266, and RMAS

Not long after the development of the System/38, the IBM 5260 Retail System was announced in 1979. This system consisted of the 5265 and 5266 point-of-sale terminals and the Retail Merchandise and Audit System (RMAS) application programs. The 5260 system provided retailers with an electronic cash register that collected, stored, and forwarded user-selected data on each of their transactions. The information, stored on diskettes, could be hand-carried, mailed, or transmitted by telephone lines to a central processing unit, which then provided a complete picture of a business's activities on a daily basis. The 5266 had no diskette storage. Innovations in this system included a unique new processor, a very low cost printer, an integrated diskette file, and closed code architecture that allowed users to personalize the system to meet their own specialized business requirements. One year later, IBM announced the 5280 Distributed Data System, also produced in Rochester.

A member of the Rochester development team points out a menu feature on the IBM 5280 Data System during family demonstrations held at IBM Rochester.

IBM System/36

Among the new products introduced in 1983 was the System/36. The project for System/36, the follow-on to System/34, began with an initial business proposal from Rochester's New Business Systems (NBS) organization. The NBS planning organization was called upon to access, understand, and document requirements for the new system, taking into consideration a vast amount of information supplied from many areas inside and outside IBM. The new product requirements for System/36 became the responsibility of Jeff Robertson, NBS manager, in the late 1970s and early 1980s. IBM designed this system to be installed by users. The System/36 combined data processing, word processing, business color graphics, and office management functions in a low-cost computer system. It operated as a stand-alone computer or in a network communicating with other System/36s or with larger IBM computers, and it used 5250 workstations or other devices that attached to the System/34, IBM's most widely used general purpose computing system at the time.

The IBM System/36, announced on May 16, 1983, combined data processing, word processing, business color graphics, and office management functions in a low-cost, easy-to-use computer for first-time and experienced users. The System/36 was designed with exceptional configuration flexibility to satisfy a wide range of users. For example, customers could use the IBM 5362 system unit, a very compact, entry-level model that offered main storage from 128 to 512 KB, and disk storage from 30 to 120 MB. The company also offered the IBM 5360 system unit with main storage of 128 to 1024 KB and disk storage of 30 to 400 MB; available in 12 models.

The System/36 5360 system unit offered 128 to 512 KB of main storage and 30 to 400 MB of internal disk storage – up to twice the maximum main storage and one-and-a-half times the direct access storage offered with the System/34. Disk storage was provided by two other products developed and manufactured in Rochester, the 21ED (Spartan) and 10SR (Star) files. The 5360 unit consisted of a series of modules, field-replaceable elements, making repairs quick and easy. Its architecture was designed around specialized microprocessors, each controlling a separate system component or function. This multiprocessor design allowed many of the system's various functions to operate independently of one another. Another feature of the system's design

was online problem determination, which told the user whether the problem was in the hardware, software, or in a communications link such as a telephone line or modem. Improved packaging contributed to product reliability – 10 times that of the cards on the System/34. It had a reduced number of logic modules: from 64 on System/34 to 19 on System/36. The system also went through constant self-checking.

Computer System Innovation Process at IBM Rochester

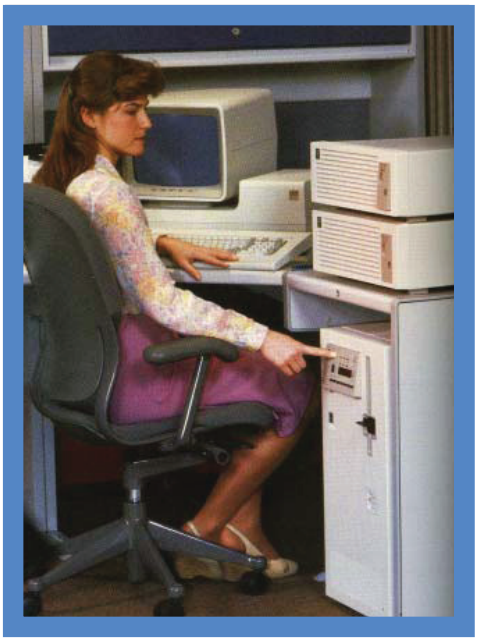
During the development of each of the systems, IBM Rochester personnel continued to change the process for development and production. Data processing systems begin with an idea that is fed and nurtured by many people before it becomes a reality. Throughout this cycle, its logic, design characteristics, and progress is checked and tested by hundreds of people. As the system evolves into a working prototype, other people constantly check and monitor its physical makeup and effectiveness. Before it is approved for market, a final review is made of its potential by corporate headquarters. Finally, after several months or years of development and preparation, the product is introduced to the world. Definition, design, development, manufacturing, announcement, and shipment are all stages in a detailed cycle occurring during the evolution of a product. Throughout the cycle, there is constant review and evaluation in an attempt to bring users the most mature, best possible system and solution. While the phases may change or vary from product to product, the final goals, bringing efficiencies and solutions to customers, do not.

To appreciate what a large undertaking a new design is, consider that the development of a competitive product requires developers to know what is needed by users. This is in contrast to the development technique of an earlier period when companies developed a system they believed would be useful and presented it in the marketplace. IBM was particularly successful with this technique when they developed the 700 series, the 650, the 1620, the 1400 series, and, most of all, the System/360. By the late 1970s, through their research, marketing divisions supplied information that helped to determine what kind of system would be successful in the current market. Valuable input came from the customers. This information, along with current product trends of IBM competitors, helped to develop a picture of what would be needed in a system.

Requirements for a new system were compared to existing systems to see if the present systems could be enhanced or if a new system was needed. For each subsequent system, the design requirements for an international audience became more and more apparent. The design needed to factor in the requirement of supporting the languages and character sets across the world. Once the requirements had been determined, the product-to-be typically went into its definition phase, where virtually every organization on site, along with marketing, world trade, service, and corporate groups, interacted in an exchange of ideas that ultimately resulted in a new product. In Rochester, the New Business Systems programming and engineering groups both played key roles in the development cycle. Working together by incorporating input from many areas, the engineers and programmers determined if the established requirements for the new product were going to work with the capabilities and technologies that existed in those areas. In programming, specifications were written for two main types of development programming during the planning phase of the cycle: System Support Programming (SSP) and Program Products. SSP helped the user get into the system by providing a set of external interfaces and related functions that tell the system what to do. Program Products provided the language and utilities part of the support that enabled users to write their own programs or applications. Engineering was concerned with the system hardware – the design, architecture, power supply, logic memory functions, microcode for device and customer functions, disk and printer adapters, communication adapters, card packaging for carrier chips, mechanical packaging of cards, design of frames, covers, cables, and connectors, as well as overall reliability, availability, and serviceability. The interplay between these two groups ensured a well-functioning system.

Next it was time to engage people from the manufacturing area. Prototypes were built by engineering, and the manufacturing employees were brought in to see how the systems were designed and to learn what types

of tests they would need to perform. Manufacturing consulted with procurement and production control to understand their capability of producing system parts like power supplies and other components. Interactions with other IBM locations determined what help they could offer Rochester in meeting its objectives. This included interactions with IBM translation centers around the world to translate the software into the native languages for the countries where IBM intended to market the products. The requirement was to support a translation and verification process that ran in parallel with development to support delivering approximately 50 national language versions concurrent with English at the general availability (GA) of the products. There is a total team effort in IBM. From the initial business proposal through the development, design, and eventual qualification for shipment of a product, the intricate interchange of information from nearly every facet of the business demonstrates a team effort in meeting schedules and objectives.



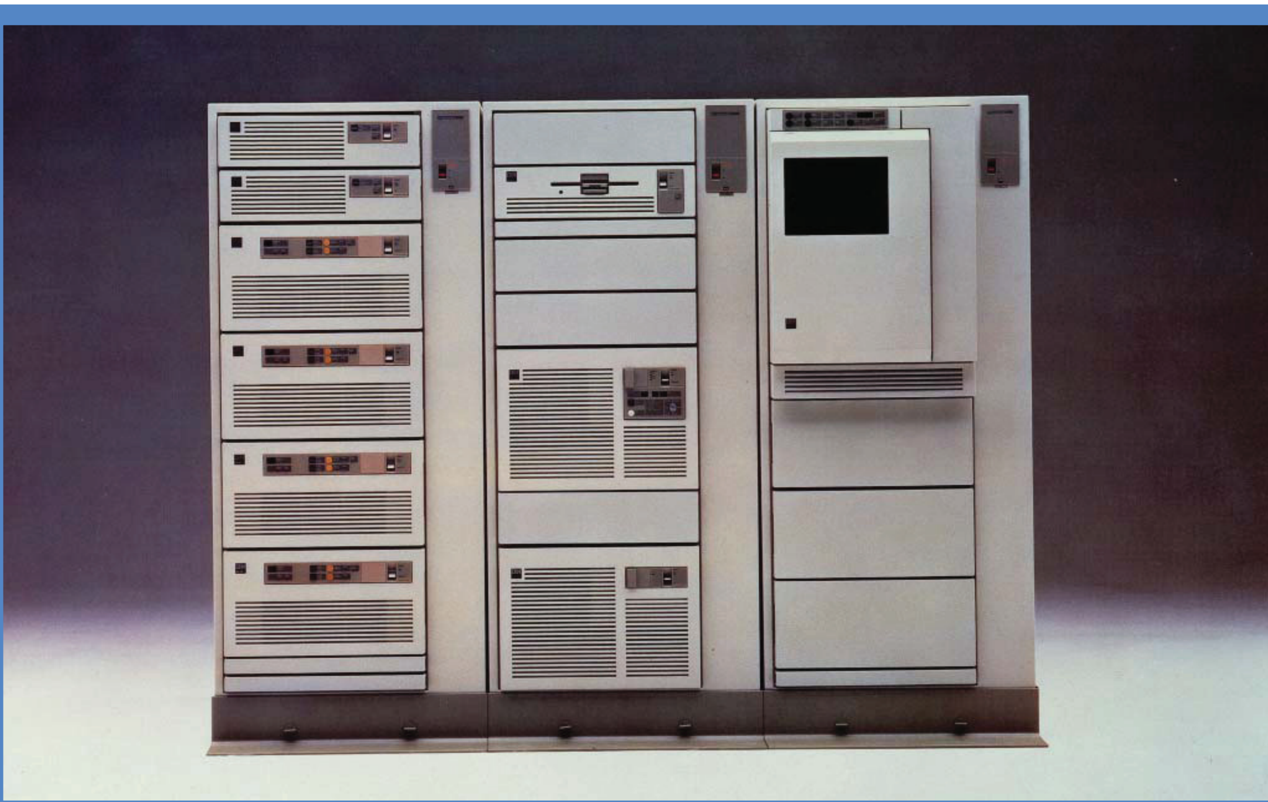
The System/36 was developed in Rochester's laboratory and manufactured in Rochester; Guadalajara, Mexico; Fujisawa, Japan and Santa Paloma, Italy. In May 1986, IBM delivered its 100,000th System/36 – which was built in Rochester – to Continental Insurance's headquarters in New York City. By 1994, the System/36 was effectively succeeded by the IBM AS/400 midrange computer family, and IBM was advising customers to trade in their System/36s to receive credit toward the purchase of an AS/400 9404 Model 135 or Model 140.

This was true with IBM Rochester's System/3 which was designed and manufactured in the late 1960s. The success of System/3 led to the refocusing of the development laboratory to design more products. The heavy influx of new systems in the 1970s led to increased cooperation between the development laboratory and manufacturing. By the time System/36 and System/38 were shipped, this new association paid handsome dividends. Management saw a way to reduce the time involved in design, development, and manufacturing by making this association a permanent one from the start. This structure achieved its greatest effectiveness with the Silverlake Project that produced the AS/400 in the second half of the 1980s.

PHASE III

Silverlake Project

In December 1983, Tony Mondello became head of the Rochester development laboratory. At the time, the corporation was pushing to have systems designed with a greater degree of parts commonality with less duplication of effort on the part of people working on them. In the fall of 1984, Mondello reorganized the laboratory. He assembled the programmers from various product-oriented groups into the Rochester Programming Center. In the new center, program development became more efficient. There was less competition among programming groups once they became part of one unit. Independent groups still worked on releases for certain products, such as the System/36 and System/38, but the groups converged on one set of tools for use by every group. The System Engineering and Planning functions, along with the Systems Management focus, became part of Advanced Information Systems. Mondello maintained separate responsibilities for System/36 and System/38. These changes were the beginning of a newly defined focus for the development of new systems at Rochester. He also had a different concept of how to work with customers – a much more open, interactive style for customer and field personnel. Tom Furey, who replaced Mondello as laboratory director, had the same outlook and carried it even further than Mondello.



On June 21, 1988, IBM introduced the Application System/400® (AS/400), a family of easy-to-use computers designed for small- and intermediate-sized companies and other organizations. As part of the worldwide introduction, IBM and IBM Business Partners worldwide rolled out more than 1,000 software packages in the biggest simultaneous applications announcement in computer history. It offered double the performance of the System/38 and five times that of the System/36.

Seen here are the AS/400 B-series models (IBM 9404 and IBM 9406), which illustrate the varying sizes and configurations available in the initial offering. The AS/400 family included six processor models, offering a 24-fold growth range in main memory, a 48-fold storage capacity range and a 10-fold performance range, as measured in commercial transactions processed per hour.

By the mid-1980s, the capabilities of various IBM computer systems were beginning to seriously overlap. At the time, five separate IBM systems – System/36, System/38, Series/1, the 8100 system, and the low end of the System/370 – were competing for the same customers. A corporate wide project, called Fort Knox, was initiated to build a totally new system to replace several of these computer systems. For some at Rochester, becoming part of Fort Knox was traumatic. They were used to building their own designs and were in competition with groups at other locations who were also building systems. In Fort Knox they needed to cooperate on architecture and marketing strategies. The Rochester engineers perceived some of the Fort Knox hardware – processors, buffers, channels, and I/O devices – as good designs. But as David Schleicher, the lead programming manager, pointed out, the architecting – the microcode, software, and applications platforms – was simply a reinvention of designs already available at Rochester. Eventually the discussions in Fort Knox became so complicated in trying to reach a commonly accepted design that the project was cancelled. Nevertheless, engineers in the Rochester development laboratory began to examine whether the System/36 and System/38 could somehow be merged without the umbrella of an organized project. Participants from the System/36 and System/38 programs got together with people from the advanced technology organization in the laboratory to design and prototype a new system. At first, H. Mitchell Watson, the president of the Systems Products Division, would not authorize any project to merge System/36 and System/38 into a new system. Late in 1985, Steve Schwartz replaced Watson, and he became enthusiastic about the concept and authorized a project in December 1985. This became the Silverlake Project, and in a very short time, this project would yield the first AS/400 models.

The timing was not optimal at Rochester because less than three months later Tony Mondello was promoted to group director of systems development for the Information Systems and Storage Group in Harrison, New York. He was succeeded as laboratory director by Tom Furey. Furey came from the Information Systems Communications Group in White Plains, New York, where he was director of telecommunications strategy development. Furey had held numerous positions in his 22-year career with IBM, from systems development and design to strategy and business planning to marketing and sales, and he performed well as a manager. He spent the majority of his career at IBM's Kingston, New York, site and was administrative assistant to John Akers when Akers was group executive of the Information Systems & Communications Group. Laboratory personnel were uncertain how, given his experience, he would be able to oversee such a forward-looking project as Silverlake. Fortunately, this concern proved unwarranted.

In the summer of 1986, Furey set out again to restructure the laboratory making some significant changes in the organization established by Mondello. His goal was to get all the people in the laboratory working together on the Silverlake Project. He assigned the task of reorganization to a cross-functional team of 10 people from various parts of the laboratory. The team recommended a laboratory of four distinct groups, each with its own very specific mission. The advanced technology group was refocused to bring IBM's new technologies to Silverlake. There was also a group to handle already promised upgrades to System/36 and System/38. A third group was to lay out a strategic plan, not just for the introduction of the new computer system, but also to look out five or more years to identify succeeding generations of the new system. The last group was to handle the human resources function for the laboratory. With the acceptance of the blueprint, Furey picked a team to lead the groups. James Coraza, David Schleicher, and James Flynn were responsible for separate areas of the advanced technology group, Coraza for system management and development, Schleicher for programming, and Flynn for hardware engineering. During this time, everyone in this group came to understand the end game and saw themselves as part of one team. Jeff Robertson headed the group handling upgrades to System/36 and System/38, Victor Tang took charge of the group looking into future strategy, and Roy Bauer headed the group on human resources.

As Frank Soltis, a technical assistant to Furey, wrote, the merger of the System/36 and System/38 groups was not easy because each group had strong emotional ties to their own architecture and their own customers. The System/36 group could not understand how a big, memory-hungry architecture such as the System/38 could ever satisfy the needs of their small customers. They pointed to the fact that the System/38 took megabytes of

memory, while the System/36 required only a few hundred kilobytes of memory, but the decision was made to use the System/38 architecture for the new system and fit the System/36 applications to it. As the two groups worked together, they found the systems to be more alike than they had first thought. They also found that various features of the two systems complemented each other. For example, the System/36 had a better user interface, while the System/38 had a better application development environment. The System/36 used separate intelligent processors to perform I/O operations, which worked better than the System/38's I/O channel. They were thus able to add the best features from each system to the AS/400.

Programming practices also changed. Programmers had always had a process at Rochester for developing programs and systems software that allowed for change. They were change-oriented. Every release of software came out with many modifications. What they did not have was the basis for a continuous integration of change. They built tools for the process that allowed them to build the system piecemeal and make alterations every step along the way. Putting the pieces of platforms together required creativity, but the real innovation was how they built them. With Silverlake, Rochester committed to very short time limits to build the system, initially without a substantial design-build plan. Programming managers had to prepare a high-level build plan with dates, but they did not have the underlying nuts and bolts to achieve it. They were learning as they went along. Building blocks were put together and turned into a prototype, and other parts were added. Systems were designed by trial and error. The documentation was minimal. When they believed that the program was robust enough, they shared it with many people who mattered, including those who would buy the system. These two things – continuous change/integration and early access to customers – made the AS/400 successful.

From the beginning of his tenure, Furey surrounded himself with a group whose experience covered all the relevant areas from architecture to programming. Emulating, but also extending IBM's typical practice, Furey brought manufacturing and control production into the product development process even earlier. With some new manufacturing procedures under design, namely continuous flow manufacturing and automation with robots, they were attempting to speed up production as well. The two groups, working ever more closely together, set out to create the new product, the AS/400, in record time. They succeeded in halving the time from concept to delivery. Rochester shipped the first AS/400 in 1988, just 26 months from the start of the project, which was half the development time of the preceding product.

In a developing trend in IBM, customers became part of the design and development process for the AS/400. Rochester set up a machine room with a mini laboratory. With modified equipment based on the Fort Knox hardware, running System/38 architecture, they eventually got the System/36 applications running. The applications ran without change and were significantly faster than what they were on the System/36. The group set up a kind of theater in a machine room with temporary walls, some drapes, and chairs, and started inviting decision makers in the laboratory and in the division to come and look at the developing computer system. Later, developers, customers, and third-party software vendors were invited to the IBM site and allowed to work and comment on the new system. These guests worked along side the software developers. There was plenty of opportunity for feedback, which effectively helped both sides. In this way, IBM dropped its previous practice of keeping everything confidential until shortly before product release. Bringing in hundreds of application developers and customers was really considered revolutionary. Even though the corporation was moving in a direction with its new design of partnership roles that is prevalent in IBM today, Rochester served as an innovator of this process within the corporation.

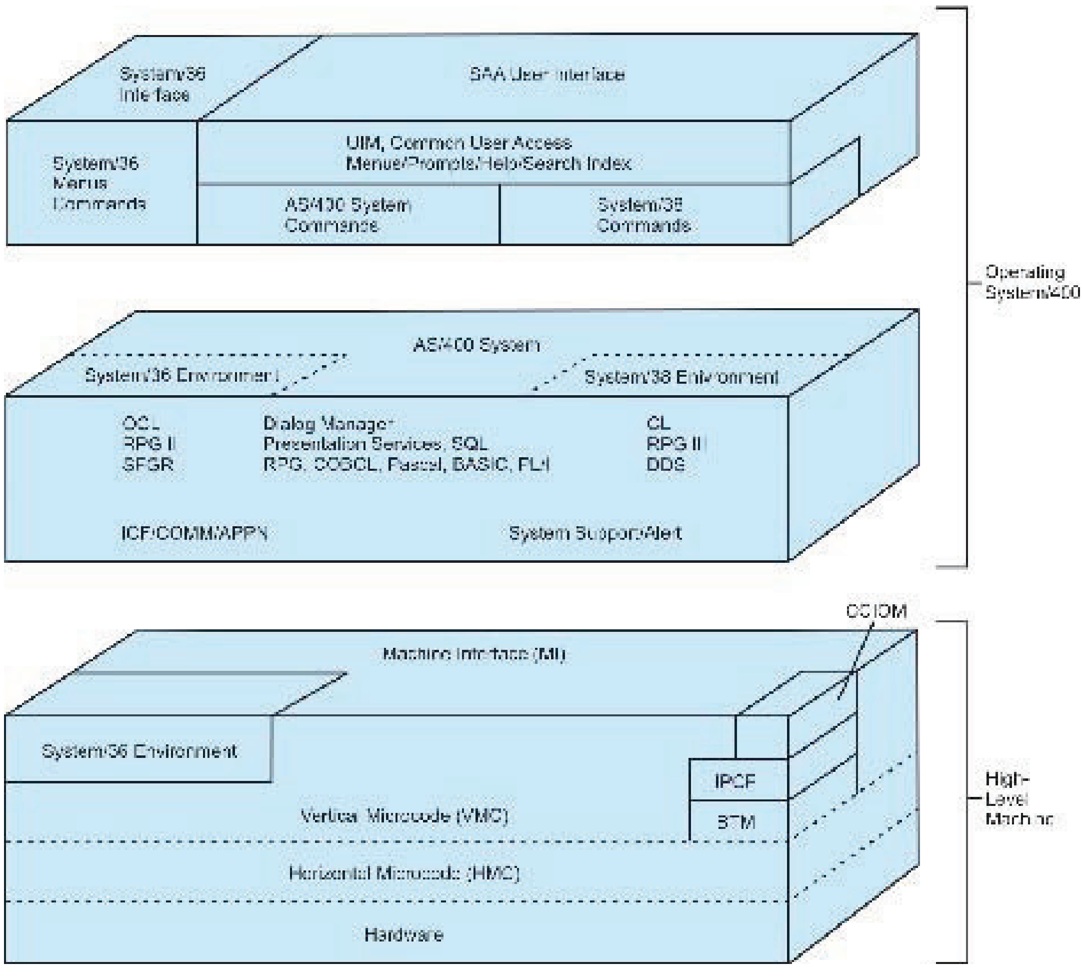
IBM AS/400

The AS/400 was a new general purpose, midrange generation of computer systems, designed for small and intermediate-sized companies or distributed locations of large corporations. It was designed and built to combine the strengths of its predecessors. This included the System/36's large application portfolio and wide range

of connectivity options, and the System/38's programmer productivity, advanced architecture, and integrated database. Significant new functions were added to enhance ease-of-use and connectivity and to support IBM's Systems Application Architecture® (SAA®), online education, and direct electronic customer-to-IBM support. The hardware was composed of the latest in IBM's Very Large Scale Integration (VLSI) chips, main storage, and disk technologies. It was managed by a single operating system.

An application orientation was the driving force behind the major design and implementation decisions for the AS/400. Examples of facilities intended to make application use and development highly productive included: conservation of existing application interfaces; integration in the system of data description and manipulation facilities to a relational database; consistent interfaces to all forms of work management including interactive, batch, office, and transaction processing; application development languages and utilities exploiting system functions; comprehensive communications features provided through device- and protocol-independent interfaces; query functions intended for general users; compatibility with IBM Personal Computers and Personal System/2; and system management utilities supporting system operation.

To support all these features, the AS/400 architecture was structured in layers separated by opaque interfaces. It integrated system function through these layers to unify function. The system allowed the introduction of new technology by exploiting the opaqueness of the interfaces and it optimized application execution for distributed processing. Finally, it ensured the separation of program specification, data description, and system operation. A single, device-independent addressing mechanism handled main storage and all auxiliary storage utilization.



The AS/400 system structure.

The system software was similarly designed in layers. Programmers designed a horizontal microcode layer, a vertical microcode layer, and an operating system layer on top of that with applications, languages, and tools on top of that. Finally, the user reached the application. Structurally it looked long, but from an application perspective, it was very short. This was the underpinning of IBM Rochester's continued presence as a general-purpose leader in computer systems for the last 25 years of the twentieth century. The end-user interface provided menus, prompts, help facilities, etc., supported by the User Interface Manager (UIM), which enforced the SAA interface standards. A control language provided consistent access to services for end-users and application programs. A number of programming languages, utilities, and programmer services were available to develop application programs. Data, file, and screen-definition languages provided external interfaces for device, communication, and database file description. Interfaces allowed System/36 and System/38 applications to execute as though they were on these systems to permit easy portability of application programs. An SQL query interface allowed end-user access to the integrated relational database equivalent to utility or high-level language access. The ability to support true data abstraction through information hiding is the most significant feature of the object orientation of the AS/400 family. An object in this system was split into a specification part and an implementation part, with only the former seen by a customer. Inadvertent or unauthorized modification of the object could not occur, since the customer could perform only the restricted operations permitted by the definition of the object. This decoupling of use from implementation allowed problem repair or functional enhancement without any impact on the customer.

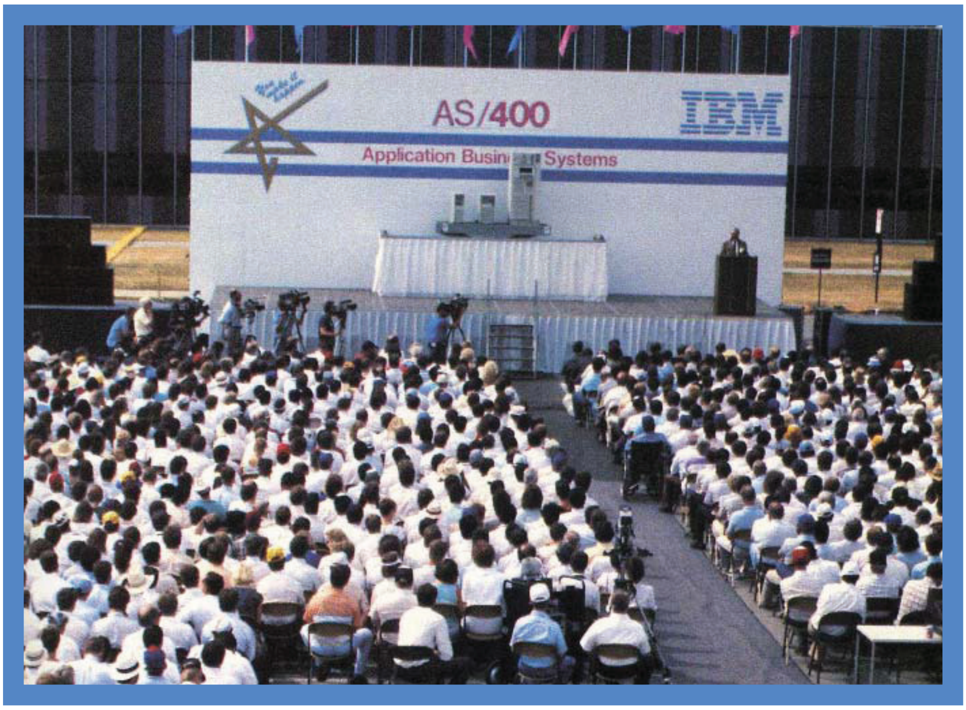
A key design requirement in the implementation of the AS/400 family was the dramatic change in the underlying architecture that was necessary to support the distribution of processing among multiple systems within a customer enterprise or among many different enterprises. The AS/400 used the densest standard cell and gate array chips ever used in an IBM processor up to that time.

IBM patented the horizontal microcode, which was tied to the processors, a new innovation. The high-level machine interface was at the vertical microcode level and it was heavily patented as well. All the sub-functions of operating systems – storage management, process management – and how they worked were also heavily patented. Many patents were written on integrating databases into an operating system so that one could basically access data at the operating system level out of the database as opposed to having to go back up to an application. In this way, there was a horizontal path to a database.

Assembly of one unit of the AS/400.

The AS/400 was introduced by IBM in June 1988, in the largest simultaneous worldwide announcement in computer history. As part of this introduction, IBM and IBM Business Partners worldwide announced more than 1,000 software applications. The AS/400 family included six processor models, offering a 24-fold growth range in main memory, a 48-fold storage capacity range, and a 10-fold performance range, as measured in commercial transactions processed per hour. It offered double the performance of the System/38 and five times that of System/36. Some people think System/38's innovations were overshadowed by the AS/400, because so many innovative features of System/38 were later incorporated into the AS/400. For example, System/38 had an integrated system architecture, design and implementation with access to a relational database, and all programming languages were enhanced to leverage these features. A number of complex software functions were integrated into hardware. System/38 possessed a single-level store, where main storage is a cache for

permanent storage and one copy of an object existed for the entire system. The system had integrated security and a consistent display-oriented interface to all system functions. The innovations of the AS/400 clearly stood on the shoulders of the earlier systems developed in Rochester.



IBM employees gather outside the Rochester site to celebrate the announcement of the AS/400 in 1988.

In the first four years, IBM shipped 200,000 AS/400s, while 300,000 System/36s and System/38s remained in service. From mid-1988 to the end of 1992, the reliability of the AS/400 family improved more than 20-fold, the quality of its operating system improved six-fold, and the price/performance ratio showed gains of 30 percent a year. In July 1991, *Datamation* reported that IBM's revenue from the AS/400 family was approximately $14 billion, greater than the total income of the Digital Equipment Corporation, which was second only to IBM's revenue.

IBM introduced a new generation of AS/400s – called the AS/400 Advanced Series – in May 1994. The AS/400 Advanced 36® was a replacement option for the IBM System/36 using a powerful new 64-bit RISC processor based on PowerPC® architecture. RISC engines gave the capability to do many things on the new AS/400 models that could not be done on the first models. Because RISC engines were built to be stacked, they would run significant parallelism. Multiple processes could be working on an application stream that could all work at the same time, at very high speed and very high throughput. IBM also produced a portable model in the series. PowerPC architecture was originally designed to support applications on a single-user workstation. To make this architecture usable for a multi-user, multi-application system, IBM Rochester needed to add a great deal of functionality to the base PowerPC definition to support the single-level store, decimal arithmetic, high-speed data movement, improved branching, fast call/return, and other functions needed in a commercial server. The AS/400 family took another turn in 1997. To provide an advantage for its customers using the Internet, IBM announced a new family of AS/400 servers. Over the next few years, IBM placed servers that were even more powerful in the marketplace. Each new addition to the family possessed more power and the price/performance ratio continued to increase.

Capitalizing on Quality as a Core Competency with the AS/400 and Beyond

IBM is a corporation that has had a strong focus on quality from its early Hollerith tabulating machines to the present. This commitment to quality has been evident in IBM Rochester's manufacturing, its development laboratory, its pioneering and supporting work on hard disks and disk drives, its achievement and success in midrange systems, its transformation of the AS/400 into IBM's eServer™ iSeries™ and IBM System i™, and its development of new businesses. Along the way, many quality measures have been instituted. In the late 1980s and the early 1990s, a time in which the IBM Corporation was facing a number of challenges, the firm placed a special emphasis on achieving ever-higher quality. This included instituting a six-sigma strategy, a focus on cycle time reductions, increased educational initiatives for a more flexible workforce, and Manufacturing Skills Integration (MSI). The Baldrige assessment discipline was used to align these efforts into a managerial structure focused on customer satisfaction. Testimony to Rochester's success was winning the Malcolm Baldrige National Quality Award in 1990 based on the work of its AS/400 division.

The all-in-one System i5™ line, announced in January 2006, helps small and medium businesses with the complexity of IT operations and delivers excellent performance with its POWER5+™ processor, a dual-core system on a chip that runs at speeds up to 2.2 GHz. The System i5 offers broad application choices across four operating systems. System i™ is the successor to the AS/400 and iSeries line of servers.

In 2004, IBM Rochester's iSeries software development organization achieved CMM Level 5, the highest level of the industry-recognized Capability Maturity Model. The group's attainment of Level 5 in its first formal assessment is a very rare accomplishment and a reflection of its strong quality culture and commitment to continuous improvement.

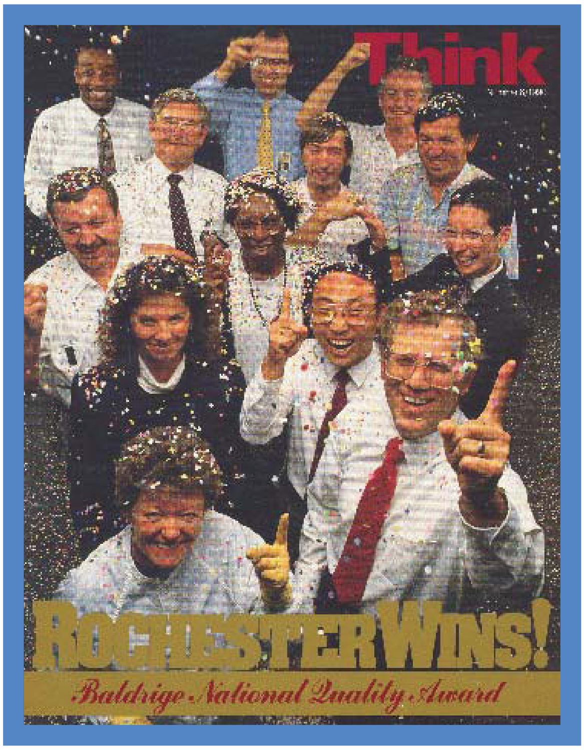
IBM is a firm with great talent, but in Rochester they also benefit from a workforce that continues to be especially dedicated and driven to succeed, and one that possesses a particularly strong work ethic characteristic of the Midwest and the state of Minnesota. These qualities naturally contributed to IBM Rochester-embraced quality practices and processes throughout the site. Those practices also extended to how Rochester employees interacted with customers and suppliers. These qualities also likely contributed to the site providing leadership

within the corporation in pioneering various quality mechanisms or certifications. This included obtaining ISO (International Standardization Organization) 9000 certification for its quality management system in 1992. In 1997, Rochester was designated one of the pilot sites for the entire corporation for ISO 14001 registration. Rochester's high standards in environmental management provided a successful platform for 14001 implementation, and the site was registered to the standard. More recently, in 2004, IBM Rochester demonstrated its superior quality focus and process maturity in software engineering by achieving CMM Level 5, the highest level in the industry-recognized Capability Maturity Model (CMM). It is rare for an organization to achieve Level 5 on the first application.

Customer-driven quality, a dedication to providing opportunities for employees to further educate and re-educate, and working closely with customers and suppliers, lay at the heart of successfully developing the AS/400 in a mere two years. The firm demonstrated a deep commitment to giving its employees the tools they needed to succeed, and benefiting from the expertise of a long-term stable workforce. IBM Rochester also exhibited its trust and cooperative capabilities in involving customers and suppliers in every aspect of the product, from design to delivery, and ensuring future quality performance through a series of feedback mechanisms. IBM Rochester's production suppliers became partners that the firm worked very closely with to mutually improve problem-solving capabilities, and to both teach and learn from, in order to drastically reduce waste of all kinds in the production process. The AS/400 was a great achievement, but in many respects, it was drawing from capabilities, expertise, methods, and commitment that had been developed and extended over many years. With a constant view of the future in mind, IBM invested the equivalent of five percent of its payroll in education and training employees during this time, a decision that paid dividends for the Rochester site and the corporation with the AS/400 and beyond.

During this time, IBM Rochester also benefited greatly from the corporation's commitment to investing in processes and practices to assure long-term continuous improvement across a wide range of quality metrics. In the second half of the 1980s, IBM spent more than $300 million in improving internal information systems alone. At the same time, IBM Rochester had achieved something special with the AS/400. Its commitment to quality throughout the site and supply network was instrumental to achieving vast reductions in product development cycle time at the end of the 1980s with the AS/400. This achievement was recognized when IBM Rochester won the Malcolm Baldrige National Quality Award. As part of this award, IBM Rochester conducted numerous and extensive sharing sessions with external companies.

IBM Rochester's success in achieving ever-higher levels of quality through disciplined mechanisms and customer and supplier partnerships would also serve the site and the corporation well as it developed and succeeded in both the extension of existing businesses (the midrange area with the IBM eServer iSeries) and the creation of new businesses and opportunities. Often this involved partnering with other IBM facilities and leveraging the research and capabilities of IBM overall.



In 1990, IBM Rochester was awarded the Malcolm Baldrige National Quality Award, the highest award in the United States for quality, by U.S. President George H. Bush.

PHASE IV

Innovation in Systems, Software, and Services, and Developing, Enhancing, and Converging Resources and Capabilities

Over the past decade, IBM Rochester has continued to be a place that the corporation looks to for quality and efficiency in developing, manufacturing, and refining important new products and services for the market. The site has broadened its presence and importance in strategic, relatively complex areas of manufacturing and development.

In February 1997, IBM shifted its business computers that were based on the Unix operating system from the Austin, Texas, facility to Rochester. In 2003, IBM Rochester emerged as one of the key multi-brand complex configurable locations for the corporation. It, along with other IBM sites, took part in corporate-wide planning to examine where different locations in North America and the world could create efficiencies and optimize corporate resources globally. As a result of capabilities possessed by Rochester employees and value propositions the site has offered, Rochester has become IBM's sole manufacturer in self checkout systems, a product area previously located in IBM's Jacksonville, Florida, location. Similarly, the Print Systems Division (PSD) moved from Endicott, New York, to Rochester in 2005 after an optimization study demonstrated the advantage Rochester's manufacturing and fulfillment capabilities could provide in the high speed printer segment – a high margin product area for the firm. While the development and manufacturing of hardware has continued to be significant at the site, software development also has remained fundamentally important.

IBM Self Checkout systems help reduce labor costs, improve operations and productivity, and increase revenue for IBM clients in the retail sector. The manufacturing of IBM's Self Checkout line transferred from Jacksonville, Florida, to IBM Rochester in 2005.

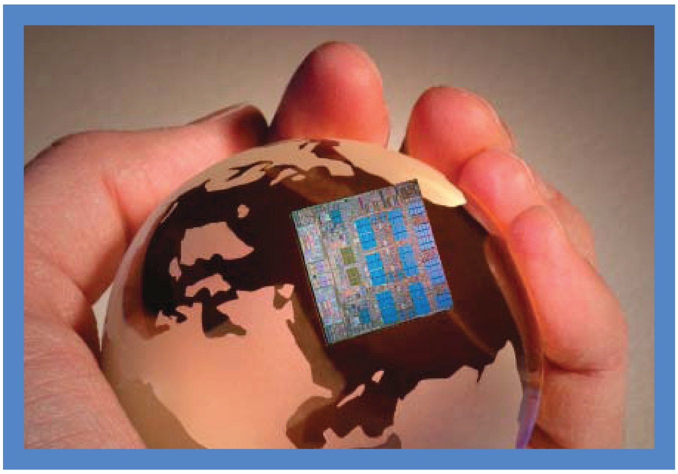
In 2005, IBM Rochester began manufacturing the Infoprint® 4100, IBM's fastest commercial printer, after high-end print systems manufacturing was transferred from Endicott, New York. The Infoprint 4100 is capable of printing Tolstoy's War and Peace in its entirety in less than a minute.

In January 1995, the three Rochester software groups, Personal Software Products, Software Solutions, and Networking Software, were combined to form Rochester's Software Group (SWG). The group has collaborated with other IBM facilities (Austin, Toronto, Hursley, Pittsburgh, and Silicon Valley) on a number of important projects, including different iterations of the WebSphere® Application Server. IBM Rochester has managed to create an entire life cycle of software from scratch based on the Software Inspection Process.

In 2004, as part of a three-year research effort, Rochester developed and shipped the Virtualization Engine™ for some of its eServer systems – providing a common construct coupled with a top layer to cater to the needs of customers – to bring advanced virtualization technology commonly associated with mainframes successfully to the midrange system server area. The Virtualization Engine on midrange servers supports business policy-based infrastructure facilitating the ease of systems management, consistent expansion, open interfaces and standards, as well as other functionality and customized elements to boost utilization and efficiency for customers.

IBM Rochester was forced to change from its inward looking ways (within the corporation, but not with regard to customers) during the early 1990s and abandoned its so-called internally-focused culture in light of new opportunities for the firm and the need to create more rational and efficient operations given the increasingly competitive global marketplace. Following the Justice Department's dropping of a longstanding anti-trust litigation in 1982, there was no justification for continuing to have facilities organized largely as independent businesses for the different major product lines (mainframes, midrange systems, and personal computers) – the firm's infrastructure could be rationalized to take better advantage of unique skills and capabilities at individual locations and to boost economies of production. This brought about a large-scale convergence between the different locations and an effort within Rochester and throughout the firm to make better use of global capabilities and to create an organizational structure that was not bound to the geographical locations of employees.

While IBM Rochester had tremendous achievement with the development of the AS/400, the great reduction in cycle time, and winning the Baldrige Award, other parts of the firm and the industry were facing great challenges. There was a slowdown in the demand for mainframe and midrange computers, coupled with a growing demand for lower margin personal computers that had descended to become a commodity. IBM suffered massive losses in 1991, only to be followed by far larger losses for both 1992 and 1993 before returning to profitability in 1994. Ultimately, these challenges forced the firm to make difficult changes that transformed IBM into a more flexible, innovative, and globally competitive enterprise. In the short-run, it brought a great deal of pain, pain that did not escape IBM Rochester, its employees, and the community. Large-scale layoffs occurred for IBM Rochester. In the short-run, this produced great hardship, in the longer-term, it probably helped to transform culture within Rochester and throughout the firm – to make it more entrepreneurial and lead its engineers to become more oriented toward new business development.



Originally introduced in 1990, the PowerPC processor was developed by IBM engineers with colleagues at Apple Computer and Motorola. It was the precursor to several follow-on POWER™ microprocessors later developed by IBM. The POWER chip is the main processor in many IBM workstations, printers, servers, and supercomputers.

With regard to IBM Rochester, another important element of this broad strategic reconfiguration resulted in a hardware convergence between IBM Austin (focused on workstations) and IBM Rochester to form IBM Server Group. This group, building on the development of PowerPC architecture, an outgrowth of IBM's partnership with Apple and Motorola, was integrated into Server Group through collaboration between the two facilities. Based on the skills of both Rochester and Austin, realizing important synergies between the facilities to achieve cost savings and to take advantage of new technical and business opportunities, IBM moved from producing competitive PowerPC-based servers in the mid-to-late 1990s to producing industry leading servers (by standard performance metrics) by 2001. The initial set of converged products that were common between Austin and Rochester came out of the Rochester laboratory, while business leadership for the common groups was maintained in Austin. The first copper processor chip was shipped in 2000 and first copper and silicon insulator chip in 2001 – a family of processors called Northstar, I-Star, and S-Star. Over the later half of the 1990s, Rochester, Austin, and Poughkeepsie continued to expand performance and efficiency in the Server Group, featuring mainframe-class reliability and scalability, support for open standards to develop new applications, and capacity on demand for addressing the accelerating and rapidly evolving needs of electronic business.

In part forced by its own success in creating efficiencies within Server Group, IBM Rochester found itself in a position where it needed to create business opportunities to best utilize its vast technical talent. IBM Rochester's Steven Lewis came up with an idea for an engineering services operation in the third quarter of 2000 and began to formalize the concept the following year. In May 2002, Lewis and other leaders from Rochester met with Ross Mauri, head of Server Group development, who immediately saw the potential of the idea. The concept fit well into the services business area of the company with its highly successful Global Services Division. The proposed Engineering and Technology Services (E&TS) proposal was an important mechanism to extend IBM's longstanding technological capabilities into the marketplace. By mid-2002, E&TS became a sanctioned Emerging Business Opportunity (EBO). Before long E&TS (part of Systems and Technology Group) was the fastest growing EBO in the corporation. As IBM Rochester Distinguished Engineer and Chief Systems Architect Darryl Solie articulated, "The idea was to provide technology wrapped in services, not just services." This group could draw on the big pool of technology, broadly conceived (people, intellectual property (IP), existing technologies, and new technologies), to solve customers' engineering problems, to allow them to deploy new technologies more effectively and more rapidly, and to create new possibilities in industries and organizations. On October 7, 2002, IBM officially unveiled this new type of service business and shifted more than 700 design engineers around the world into the unit. As E&TS General Manager Pat Toole put it, "We're taking a skills-on-demand approach to bringing customers top-tier engineers who are highly experienced in wrapping appropriate intellectual property into a solution." The offerings from the business fall in several general categories: business process optimization, e-designing, Web hosting and enablement, and technology migration and manufacturing consulting.

Medical researchers from the world renowned Mayo Clinic in Rochester, Minnesota, are pioneers in developing technology for the magnetic resonance imaging (MRI) industry. One particular set of developments centers around improvements in MRI image quality produced by devices called “MRI coils.” These devices are used in MRI imaging to scan particular sections of the body and produce high-resolution images used to assist in more accurately diagnosing injuries, health problems, etc. As Mayo researchers developed high-performance, functional prototype MRI coil units, they contracted IBM Engineering and Technology Services (E&TS) to provide design services as well as custom manufacturing services.

The work of E&TS has resulted in innovative new products such as a handheld device for traders on the floor of the New York Stock Exchange, a hands-free wearable computer, and a pacemaker programmer tool for Medtronic that enables clinicians to review pacemaker data in real time. In 2003, Mayo Clinic designed a functional MRI coil that fit over a patient’s wrist and improved diagnosis of diseases affecting wrist, forearms, elbows, hands and fingers. Mayo Clinic was interested in commercializing the device as a product for the marketplace and sought assistance from IBM Rochester’s E&TS to provide design services as well as custom manufacturing services. IBM delivered the first coil to Mayo for qualification in November 2003, and in May 2004, a new version of the coil was released (BC 103.0TChannel). This application demonstrated what was possible in bringing together Mayo IP with IBM development and manufacturing talent to produce the first Mayo-branded product in this distinguished organization’s long history. IBM Rochester continues its collaborative efforts with Mayo Clinic in an effort to improve both healthcare delivery as well as healthcare administration.

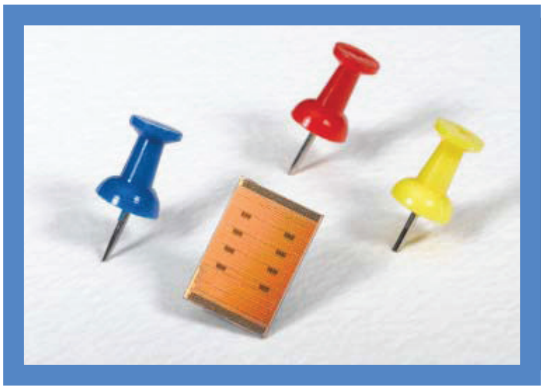
In 2004, in collaboration with the Securities Industry Automation Corporation, IBM designed a handheld communications device to process orders from the floor of the New York Stock Exchange.

In an era where information technology has diminished space, teams are put together to take advantage of IBM's talent worldwide, and reporting relationships often exist across rather than within sites. IBM Rochester's relationship with Mayo Clinic also demonstrates the importance of place and close personal interaction to achieve, in this case, new possibilities in healthcare and bioinformatics. It also shows the ability of IBM Rochester to combine and leverage its existing capabilities and the firm's excellent talent in engineering.

In reflecting on the future of IBM Rochester in the rapidly changing global economy, the site's historic strength of having highly talented and creative people that have long succeeded at solving customers' problems moves to the forefront. As Drew Flaada, IBM director for the Mayo Clinic collaboration, put it, "The whole idea of midrange computers that IBM Rochester became involved with…the System/3, System/32, 34, 36, and 38, all the way to the AS/400, really was filling needs in the marketplace that were not being done someplace else." In reflecting upon this history relative to IBM's ongoing partnership with the Mayo Clinic, Flaada continued, "We are working with Mayo, and listening to the problems its physicians and researchers are trying to solve in order to engineer new products and tools to help improve medical knowledge and patient care."

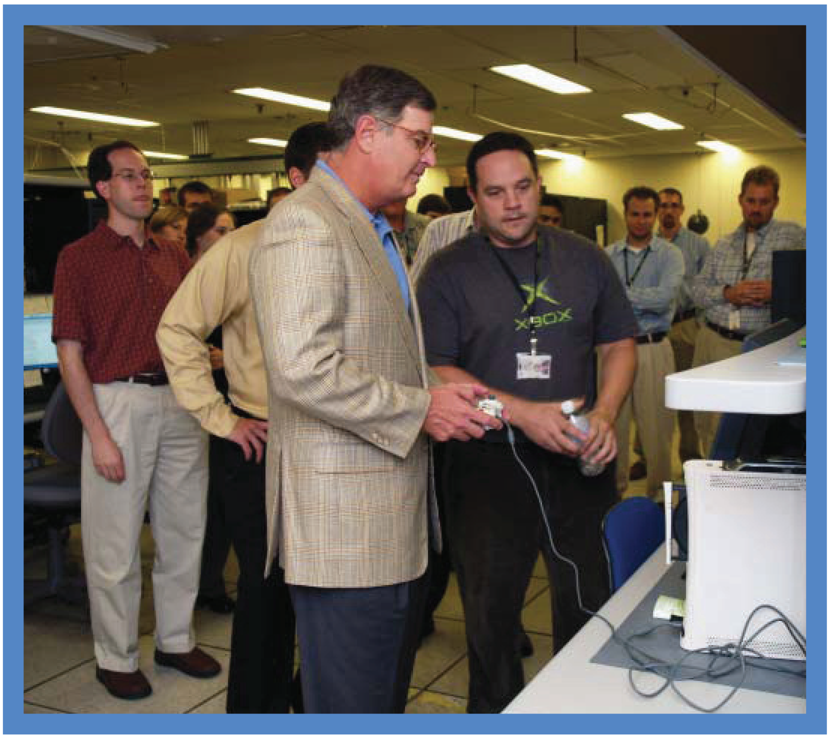
Similar practices and partnerships with customers are being employed by IBM Rochester and throughout IBM's worldwide operations to address challenging problems and to create new opportunities in other industries and domains of knowledge. In 2000, Sony approached IBM to help build a chip to go into their next generation video game console, PlayStation 3. Sony knew IBM had extensive capabilities in parallel processing on a chip and in a different context than homogeneous multi-core, or just putting multiple processors on the same chip. This led to a partnership between Sony, IBM, and Toshiba in Austin, Texas, in which Sony, Toshiba, and IBM Austin engineers worked together with engineers across IBM, including Rochester, to extend innovations of its Power architecture to develop the technology that went into PlayStation 3. In 2003, IBM began a partnership with Microsoft® in game system technology, and IBM Rochester took the lead in designing and developing the processor chip that was introduced in Microsoft's Xbox 360 in November 2005.

IBM's Cell multi-core processors, sometimes referred to as a "supercomputer on a chip," have many exciting applications and possibilities beyond the world of video games. For example, IBM E&TS' partnership with Mercury Computer Systems, Inc., resulted in the nearly instantaneous construction of three dimensional images out of several CT slices. A typical high-end server takes minutes to reconstruct a three dimensional image, a Cell chip does it in a few seconds. This is just the first application in the partnership between IBM and Mercury. As Darryl Solie puts it, "With gaming there is high demand for performance at very low product cost. This acceleration in application specific performance makes it possible to create new solutions that fundamentally change the way applications are used, real-time... for example real-time analysis of medical procedures such as colonoscopies. Affordable high performance technology will lead to solutions that have never been seen before and in many cases, never thought possible."



The IBM/Sony/Toshiba jointly developed Cell microprocessor is essentially a supercomputer on a chip. Cell features a multi-core design with high-speed communications capabilities that vastly improve graphics and rich-media applications, delivering in many cases 10 times the performance of chips used in personal computers.

IBM CEO Sam Palmisano visits IBM Rochester and the Xbox 360 CPU development team in 2005. Xbox 360 became a major phenomenon in the world of video games. The POWER-based processor was designed and developed by IBM's Engineering and Technology Services and Microsoft to meet the game system's advanced requirements for speed, acceleration, and programmability.



In the fall of 2002, IBM Research was investigating the idea of designing a supercomputer that far surpassed the technology available at the time in order to accelerate their progress in computational biology. At about the same time, the Department of Energy, along with Lawrence Livermore National Laboratory (LLNL) in California, was interested in obtaining a new supercomputer to assist with their research. In both cases, a computer that could calculate at rates of one petaflop, or a million billion operations per second, was needed. The Blue Gene® supercomputer, which began as an architectural concept at IBM Research, became reality when a cross-divisional team in Rochester, led by E&TS, joined the venture.

Developed in collaboration with the U.S. Department of Energy, the Blue Gene family of supercomputers is optimized for bandwidth, scalability, and the ability to handle large amounts of data. Thousands of dual-core POWER microprocessors give Blue Gene the capability to perform complex computations in the areas of life sciences, scientific research, and financial and climate modeling. A 64-rack Blue Gene/L supercomputer is installed at the Lawrence Livermore National Laboratory, where it achieved a record sustained speed of 280.6 teraflops in 2005.

On June 28, 2005, the 64th and final rack rolled off the Rochester manufacturing floor. Pictured here is the Rochester team with the last rack just prior to it being sent to Lawrence Livermore National Laboratory. IBM Rochester employees join to celebrate the shipment of this last rack. Bob Lytle, Bruce Buchardt, Brian Sovereign, Sophie Bechu, Andrea Eung, Steven Lewis, Curt Mathiowetz, and Danh Beckman.

While the importance of the Blue Gene project was defined around the ability to research, for IBM it was also a matter of company as well as national pride. At the time, IBM's most powerful system was ranked fourth on the TOP500 Organization's list – the world's foremost supercomputer ranking authority. The machine was about 1/5 as powerful as Japan's Earth Simulator machine, which was ranked first. For decades the United States, and in particular Minnesota, led the world in supercomputing power. By the time the November 2005 rankings were released, Blue Gene held five of the top 10 spots on the TOP500's list including the number one spot with a supercomputer that was five times more powerful than its next nearest competitor.

As the Blue Gene supercomputer project in Rochester began to grow, so did the site's involvement. Rochester's manufacturing team began building and testing the individual racks that would eventually be joined together to become the world's fastest system. On June 28, 2005, the 64th and final rack rolled off the Rochester manufacturing floor and was sent on its way to LLNL. Blue Gene/L joined another IBM supercomputer at LLNL-ASC Purple – which is used to safeguard the nation's nuclear stockpile. Upon Blue Gene/L's arrival in California, U.S. government officials recognized the achievement of both systems, which when combined, delivered an unprecedented amount of computing power – half a petaflop, or half of a quadrillion (1,000,000,000,000,000) operations per second. Both computers were developed under the Department of Energy's Advanced Simulation and Computing program, a multi-step program between industry and government, launched in 1995 to create a computer 100 times more powerful than those in existence at the time. The goal of the program was to use computer simulation instead of real world testing to certify the safety and reliability of the nation's nuclear stockpile. Along the way, the technology developed to meet that goal was responsible for many of the advances we see today in manufacturing, drug discovery, and weather forecasting.

Based on IBM's Power architecture, Blue Gene is optimized for bandwidth, scalability, and the ability to handle large amounts of data while consuming a fraction of the power and floor space required by what used to be the fastest systems. IBM and its partners are exploring a growing list of high performance computing applications including life sciences, financial modeling, hydrodynamics, quantum chemistry, molecular dynamics, astronomy and space research, and climate modeling. As Steven Lewis put it, IBM hardware and software engineers are energized to work on Blue Gene especially because "you have an opportunity to change things for humanity."

Looking at IBM Rochester in the early 2000s, the building has grown to be the largest IBM facility under one roof housing more than 30 divisions including a large development lab for both hardware and software as well as taking the lead in providing end-to-end supply chains for products worldwide. Rochester has evolved, along with the corporation, to not rely solely on the development and manufacture of products they believe their customers need in order to run their business. IBM is now devoting more of its time partnering with customers to create innovations and solutions that become part of their customers' business. By working with IBM and customer teams around the globe, IBM Rochester and its partners are on the fast path of creating new opportunities never seen before.

IBM Rochester in the 21st century.

Beginning with its first patent in 1960 by Rochester's John Lego for the assembly of a type bar apparatus for printing machines, to the hundreds of patents that are contributed annually today, IBM Rochester has continued to contribute ever more to the development of IBM's Intellectual Property (IP) portfolio. IBM has led the nation in U.S. patents for several consecutive years with 2,941 patents awarded in 2005 alone. Rochester employees and their teams have typically produced seven to eight percent of those patents. In the early years, patenting was exclusively focused on protecting IBM's product lines. Over the past two decades, and now more than ever, intellectual property development and portfolio management have become highly strategic for the corporation as licensing revenue contributes substantially to IBM's top and bottom lines. Rochester, along with IBM sites throughout the world, has been an important contributor to this transformation in making IP development (regardless of deployment) a meaningful IBM business.

More broadly, IBM Rochester has shown its ability to continually adapt, along with the corporation, to meet the challenges of an ever-changing global marketplace. Rochester recognizes that the future relies not only on developing and manufacturing the systems on which businesses operate, but on continually working to find innovations that matter in the world. With AS/400, IBM Rochester proved it was good at doing the more complex tasks and could benefit the corporation and the customer by utilizing appropriate skills and serving markets worldwide. As Walt Ling, Minnesota's senior state executive for IBM, stated:

> *IBM employees will continue to look for and work on challenging problems. That is and has always been our strength. We will work on developing highly innovative tools and solutions and create new opportunities in the marketplace and new possibilities for our customers. The world becomes a smaller place every day. Countries that, at one time in history, we may never have thought of joining forces with are now booming new markets. IBM continues to forge new partnerships around the globe, as it makes perfect business sense to take advantage of all the expertise that can be brought to the table and to collaborate on new innovations.*

Ling strongly emphasized that business starts with customers. More than ever IBM Rochester is focusing on engineering solutions for its customers in fast growing industries and fields such as medicine, finance, and defense, as well as home video games. These endeavors take highly trained, skilled, and creative people that can react and adapt rapidly – individuals and teams that are capable of creating innovation that matters in the world.

The porte cochere at IBM Rochester's main lobby entrance in 1960.

IBM Rochester's main entrance in spring 2006. The porte cochere was enclosed and became an addition to the site's main lobby in 1981.

Conclusion

This brief history illustrates how IBM Rochester proceeded through a series of phases over the years, which culminated in the dynamic, forward-looking, sharply focused activity of the site. Beginning as a partner in manufacturing, IBM Rochester followed the lead of the IBM Corporation into new data processing areas, namely the design and development of tailored computer systems customized for each user. Emerging from the shadow of other development groups in IBM, Rochester obtained its own development laboratory in its first phase of manufacturing activity. This allowed the site to broaden its interest into a domain that was emerging in the computing area, but was not yet fully focused on by the corporation – small and medium business systems. With this new idea, a second phase emerged in which IBM Rochester did as much development and manufacturing of their own designs as they did for the designs of other IBM units. Beginning with the IBM System/3 and the various follow-on computer systems, the objective was to design computer systems to appeal to various-sized businesses with different needs. In one sense, this phase culminated with the marketing of the IBM System/36 and IBM System/38. In another sense, the next phase began with the corporation's recognition of the large number of systems on different platforms. This recognition led to a program to reduce this number and provide more commonality of software and components and the opening of phase three. The merging of System/36 and System/38 into a new, more powerful and capable system – the AS/400 – provided Rochester's greatest success in development thus far. In effect, the process for designing and manufacturing this family of computers both led and followed the company into a newly developing computing activity and away from businesses that had become commodity enterprises. Meanwhile, the strengths and diverse capabilities accumulated during its first four decades helped enable IBM Rochester to move seamlessly into new types of computing, software, and particularly services, where IBM concentrates on partnering with customers to develop solutions to meet complex information technology and business needs. This new type of effort constitutes phase four of IBM Rochester's history. IBM Rochester, indeed, the IBM Corporation itself, collaborates with customers to bring innovation to their businesses by wrapping technology in services.

All along, IBM Rochester was trying to make the whole greater than the sum of its parts – its employees have shown dedication to respond to corporate direction and to recognize and respond to market needs. These strengths ensured an outcome based on sharing and a focus on the future. The men and women of IBM Rochester gave and still give their all to make IBM Rochester responsive, innovative, and successful. Even as the global economy rapidly evolves and presents more complex challenges and opportunities and requires new thinking about time-honored problems to bring about new, innovative solutions, IBM Rochester's legacy carries on into the future.

IBM Rochester's lobby and reception area in 1960.

The main lobby at IBM Rochester in 2006.

Acknowledgements

Text prepared by

Professor Arthur L. Norberg
Jeffrey R. Yost, Ph.D.
Charles Babbage Institute
Institute of Technology
University of Minnesota
Minneapolis, MN

Sources used

IBM Rochester Library and Archives
Rochester News, 1956 to 1991
IBM Archives
Charles Babbage Institute Collections
IBM Technical Publications
Other published literature

Interviews with

Richard L. Bains
Drew Flaada
Richard Hedger
Steven D. Lewis
Walt Ling
Thomas Paske
Ben Persons
David L. Schleicher
Robert R. Williams
Brad Brech
Richard Greenberg
Glenn Henry
James Licari
William J. McGinnis, Jr.
Herb Pelnar
Bruce Remme
Darryl W. Solie

IBM Staff Participation

Terri Dudek
Valerie Halverson Pace
Lorie A. Luedke
Erin Martin
Desiree Strom
Dick Ulland
Mary Welder

Photographs courtesy of IBM